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ATLIS Report No. 21

CRITERIA FOR EVALUATING THE EFFECTIVENESS OF LIBRARY OPERATIONS AND SERVICES

PHASE III: RECOMMENDED CRITERIA AND METHODS FOR THEIR UTILIZATION

January 1969

FINAL REPORT of Contract DA-28017-AMC-3483 (A)
for Picatinny Arsenal, Dover, New Jersey

John I. Thompson & Company
1118 22nd Street, N. W.
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ATLIS REPORT NO. 21

Criteria for Evaluating The Effectiveness of Library Operations and Services

PHASE III: Recommended Criteria and Methods for Their Utilization

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Date: January, 1969

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ABSTRACT

This final report assesses and recommends criteria and methods for evaluating the performance (effectiveness and efficiency) of technical library operations and services. These criteria and methods include those identified in the state-of-the-art of library evaluation (existing criteria and methods) and those developed by adoption of criteria from the state-of-the-art of "scientific management" (candidate criteria and methods).

The final product is a list of recommended criteria and associated methods of implementing them. There are 4 proposed techniques:

(1) SCORE Analysis - a technique to measure the effectiveness of a service and the associated change in effectiveness due to a change in operations or costs.

(2) SCOUT Analysis - a technique to determine the optimum balance between operations which yields maximum effectiveness within budget constraints.

(3) CORE Analysis - a technique to derive unit cost standards for given operations which produces a given quality of output.

(4) GAME Analysis - a technique to eliminate unnecessary work or excessive delays; to arrange work in the best order; to standardize usage of proper work methods, and to develop time standards to accomplish essential events.

PREFACE

This is the final report of the third and final phase of the study "Criteria for Evaluating the Effectiveness of Library Operations and Services," performed under Contract DA-28017-AMC-3483(A) for Picatinny Arsenal, Dover, New Jersey.

The first report (Phase I: Literature Search and State-of-the-Art, ATLIS Report No. 10, DDC Document No. AD-649 468) summarized the findings of a search in the library and management sciences literature and identified the spectrum of management techniques to be considered for the evaluation of library effectiveness and efficiency.

The final report of Phase II (Data Gathering and Evaluation, ATLIS Report No. 19, DDC Document No. AD-676 188):

(1) summarized data and information collected to facilitate the development of criteria for the evaluation of library efficiency and effectiveness;

(2) summarized the findings on the missions and objectives of Army Technical Libraries (A.T.L.'s);

(3) summarized the areas in which adequate standards and measures for performance are feasible, and

(4) presented tentative (existing and candidate) criteria and proposed management techniques for implementing them.

This final report of Phase III (Recommended Criteria and Methods for Their Utilization, ATLIS Report No. 21):

(1) examines the tentative criteria (existing and candidate);

(2) assesses the reliability of the measurement tools;

(3) presents a detailed description of the recommended methods of implementation of the criteria, and

(4) discusses the applicability of the criteria and methods as bases for establishing adequate standards for performance evaluation of A.T.L.'s.

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The authors acknowledge with thanks the kind cooperation of the library administrators and personnel of the Army Technical Libraries visited during the work of this study. We also wish to extend our gratitude to the management personnel of the Scientific and Technical Information Center at Picatinny Arsenal, Dover, New Jersey, for their participation in the several helpful discussions held during the progress of work in this investigation.

DISCLAIMER

The findings of this report are not to be construed as an official Department of the Army position.

I. INTRODUCTION

The purpose of Phase III in the words of the contract is as follows:

> "Using the data and information collected in Phase I and II, tentative criteria for the evaluation of libraries will be set up. These criteria will be tested and validated against a sample of Army Technical Libraries, and will serve as a basis for establishing adequate standards for performance evaluation of Army Technical Libraries. Product of this phase will include the required criteria to achieve the objective of this task, and a detailed description of the method of implementation."

In seeking to understand the requirements of Phase III so that maximum results may be realized toward fulfilling the objectives of the overall study, we were particularly concerned with the phrase: "These criteria will be tested and validated--------." We make the point, in our Phase II report when discussing the nature of criteria, that criteria comprise only one part of a whole made up of CRITERION-STANDARD-EFFECTIVENESS-EFFICIENCY. That is to say, criteria originate out of knowledge of a subject, are of a broad nature, and may even be regarded as expressing truisms. Puristically they are important, but they become useful only when implemented by practical methods. Although one could, of course, argue the soundness of any criteria on a philosophical level, it is judged more contributory to the objectives of this study to set forth the criteria as being sound and valid on the basis of knowledge of library services, operations and management, and to contend that what is needed in the final analysis are tests of the validity and reliability of the methods by which the criteria are implemented. It is by means of these methods that we assess the criteria and finally arrive at standards. And it is by means of standards that we finally achieve effectiveness and efficiency. This interpretation was discussed with the technical representative of the government contractor and found to express the purpose of the study.

We intend, therefore, in this report to set forth the criteria which this study has either found in the literature or which we have developed in the course of the work, and to describe in detail a number of methods we devised for implementing these criteria. Our discussions will describe how the suggested methods actually may be used to implement the criteria, and we will discuss the applicability of the methods and criteria to the establishment of adequate standards for evaluating performance of A.T.L.'s.

As in prior cases* we believe that it is desirable to define key terms as a basis of subsequent discussions. Two terms of considerable importance to this work are "validity" and "reliability." On the basis

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* Definitions for the terms "criteria," "standard," "effectiveness" and "efficiency" have been provided in the reports of earlier phases.

of definitions in authoritative dictionaries we define the term "valid," when applied to criteria or methods, as meaning that these criteria and methods are sound and well-founded, and that their use will produce the desired result of being able to measure the effectiveness and/or efficiency of technical libraries in a meaningful way. Our uses of the words "validity" and "validate," therefore, are simply as noun and verb forms of "valid."

The word "reliability" connotes trustworthiness. Again, out of the common definitions of authoritative dictionaries we are using "reliability" as meaning that the methods we are recommending for implementing the criteria are dependable, consistent and accurate, and will truly measure, with uniform results when repeatedly applied, the effectiveness of library services and the efficiency of library operations.

The intimate relationship between validity and reliability sometimes causes the terms to be regarded as synonymous. We wish to distinguish between them, however, and to state that while the validity of the criteria rests upon knowledge of the field, the purpose of Phase III is to test the validity and reliability of the methods for applying the criteria.

To provide continuity with the reports of Phases I and II, a few words of explanation are in order. As will be recalled from the earlier discussions, it was stated that the literature search of Phase I found a number of statements which could be interpreted as criteria. One of the tasks of Phase II was to review the findings of Phase I and to list those statements found which might be called "existing criteria." In the Phase II report this was referred to as the TYPE I APPROACH. Chapter II of the present report will list that group of criterion statements and present findings of our preliminary discussions of them with several library administrators.

In addition to Type 1, four other approaches toward developing criteria were described in the Phase II report. The rationale of Type II through V depends upon such matters as mission statements of A.T.L.'s; various operational data concerning these libraries gathered by other organizations and reported in a series of referenced documents; the examination of modern management techniques as possible methods for developing library effectiveness criteria, with subsequent selection of a limited number of such techniques as most applicable; and finally, the application of a modified specific management technique - utility analysis - to a logical development of library services and operations from the basic library statements of mission, goals and objectives. From Types II through V, certain concepts were suggested as tentative criteria in the Phase II report. These will be referred to as the contract "candidate criteria" and will be discussed in Chapter III.

The work of Phase III resolved itself into three segments. In segment one, visits were made to four A.T.L.'s, all of which were different from the 10 libraries visited in Phase II, to gather certain data and descriptive information needed for assessment of the criteria and methods. In addition to the data and information gathering motive for the library visits, we wished to obtain some idea of the informal acceptance of the criteria from the type of people, namely the library administrators, who eventually would be expected to apply the criteria and their methods of implementation. That is to say, we wanted to determine, in a preliminary way, whether or not the administrators of the libraries visited thought that the criterion statements are sound statements, and whether or not they constitute bases on which to develop standards, to measure efficiency and to measure effectiveness.

In the second segment of work, analysis and evaluation of the statements, data and descriptive information collected were made according to the methods developed and in light of the findings in Phases I and II to test the hypothesis that the criteria and methods constitute a practical basis for developing standards. In the third segment, the material was gathered into the final report represented by this document.

Only a portion of the data and information gathered was actually utilized. Not all possible criteria and methods initially enunciated were assessed. Furthermore, in certain of the explanations and descriptions of methods in later chapters, hypothetical data are used simply to illustrate the techniques.

II. STATEMENT OF EXISTING CRITERIA

To reiterate, the so-called "existing criteria" have been derived from the literature searched in Phase I and from statements made by librarians during the Phase II library visits. These criteria, as found, were not always presented by the originators necessarily as "criteria" intended to be the basis for the evaluation of library performance. Some of them were stated as being "policies," or perhaps "standards," or "rules." Or they may have been presented simply as principles upon which library performance, or efficiency or effectiveness might be based. In certain cases, some of these criteria have been developed to a rather high degree of sophistication, utilizing measures such as recall and relevance ratios. But most of them are general statements without the associated methodology necessary for implementation, and without any suggested basis for quantification or measurement. Nonetheless, in our investigation of the matter all statements, regardless of their state of development, identified as being existing criteria were examined by our staff as to their usefulness in developing methods for measuring efficiency and effectiveness.

Thirty-seven existing criteria were identified, drawn together in a summary form, and exhibited to the administrators of the four libraries visited in Phase III. These criteria are as follows:

1. The library should support the total organizational program and goal.

2. The library goals should support the goals of the parent organization.

3. The library goals must be explicit as to extent of service and priority requirements.

4. The role of the library is determined largely by requirements for library services of the laboratory served.

5. A technical library's mission is to provide technical information.

6. A college library should be directly responsible to the college president.

7. A library should publicize its services so that the users know they exist.

8. Library goals must be agreed upon by management, library administrator and users.

9. A budget for a special library should be based on recommendations of the library administrator.

10. The library administrator should have the responsibility and authority for the expenditure of his budgeted funds.

11. One of the criteria of a profession is the existence of a systematic body of knowledge of substantial intellectual content.

12. A professional should have personal skill in the application of this knowledge (see 11) to solve specific problems or to attain specific goals and objectives.

13. An adequate professional library staff is an essential component of basic research facilities.

14. The library staff should include persons trained in the users' fields who are familiar with information problems in these fields.

15. The librarians should have library training and knowledge of information sources.

16. The library staff is responsible for the efficient organization of materials and for making available the catalogs and indexes for prompt access to the materials for the patrons.

17. A job description should include a statement in detail of actual activities, indicating importance of each activity, the conditions under which the job is performed, and the materials needed to carry out the job.

18. Knowledge requirements, scope of assignment and level of responsibility should be factors in determining grade level of personnel in a government library.

19. To qualify as a librarian, a person should have five years of formal education beyond secondary school including graduation from library school.

20. A special library should acquire materials and information for the current and future needs of the organization.

21. The criteria for selection of published material should inform the acquisitioner as to the identity of the material that should be processed and also should indicate to the clients what they can expect from the library.

22. The organization's information requirements should reflect all forms of information required to fulfill the needs of research projects and technical interests of group members.

23. Subject coverage of the collection should be intensive and extensive enough to meet the current and anticipated information requirements of the library clientele.

24. The size of the collection should depend upon the amount of material available that is pertinent to the organization's needs.

25. The quality of the collection can be judged by comparison with lists of key literature.

26. Relevance ratios are a measurement of effectiveness of indexing systems.

27. Recall ratios are a measurement of effectiveness of indexing systems.

28. The catalog should be in enough detail for the users to be able to use it efficiently.

29. Cataloging and classifying should be quality controlled in such a manner as to assure the highest possible accuracy and consistency.

30. Factors to be considered in developing standards for cataloging are:

    a. cost
    b. physical dimensions
    c. time to construct
    d. time to maintain
    e. time to search
    f. scope of topic
    g. ease in determining relevance
    h. number of access points as main entry
    i. universality of terms
    j. rate of growth per new entry
    k. obsolescence rate
    l. simplicity of apparatus
    m. adaptability to reproduction

31. Ease in accessibility is the most desirable characteristic in an indexing system.

32. Ease in accessibility is the most desirable characteristic in a document storage system.

33. The physical location of materials should be determined by the amount of use.

34. Success in locating materials is more significant than the number of volumes in the collection.

35. The amount of successful use of a library is the ultimate test of its effectiveness.

36. The special library should provide successful reference service varying from answering miscellaneous questions to providing literature surveys and comprehensive bibliographic reports.

37. The library staff should locate library materials and information promptly upon request.

"Existing criteria" are not treated in this study as candidate criteria for measurement of performance; however, they are used in many cases in the development of candidate criteria. It will be apparent to the reader that several of the "existing criteria" are similar to those listed by the authors in Chapter III of this report as "candidate criteria." For example, numbers 1, 2, 3, 4, 20, 22 and 23 are related to candidate criterion number I of Chapter III. Existing criterion number 30 enumerates several factors which we include in statements of candidate criteria or which we develop in methods of implementation. Existing criterion number 35 is a basic statement, the implications of which we attempt to work into our considerations of cost effectiveness and utility analysis.

We are interested in having the opinions of the library administrators on the following four points:

(1) Is the criterion a valid statement?
(2) Is the criterion a basis for developing standards?
(3) Is the criterion a basis for measurement of efficiency?
(4) Is the criterion a basis for measurement of effectiveness?

Rather than report all detailed information which resulted from our questions to the library administrators on the existing criteria, it is judged sufficient to summarize the findings. The detailed data are available should they be required.

The majority of library administrators agreed that all but criteria numbers 6, 8 and 31 are valid statements. None of the existing criteria received majority support as being an adequate basis for measurement of performance (efficiency and/or effectiveness). Among other areas, there was general agreement that recall and relevance measurements taken together may be adequate measures of the effectiveness of indexing systems if, and only if, relevance can be determined. This implies that client needs must be defined in sufficient detail so that relevance can be determined, and that all candidate documents can be classified unequivocally as being either relevant or irrelevant. If information can be considered partially relevant,or relevant to any aspect of a client's need, or if

information can be considered as being potentially useful in any way to serve the user's expressed need, then a question arises as to degree of relevance. Furthermore, if the need is equivocally expressed, relevance is difficult to determine. Further research should be conducted to develop criteria for determining the degree of relevance of information to expressed needs, before recall and relevance ratios can serve as a measure of the effectiveness of indexing systems adequate for the development of standards.

Other existing criteria are viewed by as many as half of the librarians queried as being a basis for measuring efficiency and/or effectiveness. However, the majority of the librarians queried feel that the existing criteria listed have not been developed sufficiently to serve as a basis for developing standards for operations or services. Based upon this evaluation of "existing criteria" we conclude that even though valid bases for measurement of some aspects of effectiveness have been developed, a sufficient number of factors required for the development of effectiveness standards have not been measured adequately. Some of the A.T.L.'s visited in Phases II and III have adequate standards for measuring efficiency; however, the criteria and methods need refinement and the standards developed are not universally applicable. We have incorporated some of these criteria and methods in GAME Analysis (see Chapter VII) -- a technique which is universally applicable to certain operations for the development of standards.

In evaluating t "existing criteria" we recognize some works in the state-of-the-art of library evaluation as being stepping stones for future development. The importance of this background should not be taken lightly and the "existing criteria" should be exploited in areas which were not developed in this study. A comprehensive assessment of existing criteria is not attempted in this study. The existing criteria useful to this study have instead been incorporated in our candidate criteria which are assessed in the following chapter.

III. CANDIDATE CRITERIA AND METHODS OF IMPLEMENTATION

Nine basic criteria were enunciated out of the work of Phases I and II of this contract study. With the exception of one of these "candidate" criteria, methods of implementation of the concepts were also recommended. For the most part these methods may be identified as "management techniques." Although the candidate criteria and methods were listed in the Phase II report, they are being repeated here to facilitate communication in this document. The wording and arrangement have been revised slightly for better understanding, but the essential concepts remain unchanged.

CRITERION I

The effectiveness of an A.T.L. is a function of the extent to which it supports the mission of the parent organization. The mission of that library is a derivative of the mission of the parent organization. The effectiveness of the library is a function of the adequacy and clarity of its mission statement in enumerating concrete goals and objectives as well as specific library services and products.

METHOD I(a) - The function in Criterion I can be determined by organization analysis,* that is, by a study of the purpose for the existence of the organization, its function and the extent to which it accomplishes its functions.

METHOD I(b) - The function in Criterion I can be determined by research,* that is, by a study of mission statements of other libraries with similar types of clientele, to develop a model mission statement.

METHOD I(c) - The function in Criterion I can be determined by human relations studies, that is, by studies of customer oriented planning and control.

METHOD I(d) - The function in Criterion I can be determined by a planning, programming and budgeting system study, that is, by a study of the extent to which the program director plans, delineates objectives, analyzes costs and benefits, and allocates his budget to maximize benefits.

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* The management techniques, such as "organization analysis," "research" and so on, referred to in the methods statements, are defined in the glossary of the Phase II report.

CRITERION II

The effectiveness of an A.T.L. is a function of the closeness of its affiliation with the administrative level responsible for the organizational divisions served by the library. The mission of the A.T.L. is approved at this administrative level and implemented by the library administrator.

METHOD II(a) - The function in Criterion II can be determined by organization analysis, that is, by a study which identifies relationships between line and staff units within the organization. The study identifies areas of responsibility of each unit and provides a view of the distribution of responsibilities, thus making it easier to detect inconsistencies of organizational roles and goals.

CRITERION III

The effectiveness of an A.T.L. is a function of the extent to which the library administrator manages his resources to provide the combination of services and products which give optimum support to the library mission, goals and objectives.

METHOD III(a) - The function in Criterion III can be determined by cost-effectiveness analysis and by a planning, programming and budgeting system study, that is, by utilizing a "systems approach" to quantify costs and effectiveness through system simulation models. The system model facilitates mathematical modeling which can be the basis for planning, programming and budgeting decision.

METHOD III(b) - The function in Criterion III can be determined by utility analysis, that is, by utilizing the library administrator's judgments as to the value of services and operations in supporting the library mission. Basic judgments of the relative values of each service and operation are recorded in such a way that mathematical equations can be used to unify them and to resolve the balance between operations which gives optimum support to the library mission, goals and objectives.

CRITERION IV

The effectiveness of a given type of service or product is a function of the probabilities of occurrence of all events essential to meeting the objective or purpose of that service or product.

METHOD IV(a) - The function in Criterion IV can be determined by measuring, for a population of needs, the percentage of needs which pass each event required to accomplish the objectives of the services or to accomplish the production of the required products.

CRITERION V

The effectiveness of a given service or product is a function of the collective effectiveness values of all individual operations in accomplishing the events required to produce it.

NOTE: No method is offered for the implementation of this criterion at this time.

CRITERION VI

The effectiveness of a given library service or product is relative to the collective indifference (of potential users, librarians, and their supervisors) between that service or product and other services or products needed to meet their respective objectives.

METHOD VI(a) - The relationship in Criterion VI can be determined by subjective analysis of the value or utility of each service or product in supporting the mission of the library and the mission of the parent organization, and by assigning weights to reflect the relative value of each service or product.

CRITERION VII

The efficiency of a given library operation is a function of the unit cost and quality (effectiveness) of the operation's outputs.

METHOD VII(a) - Where high correlations exist between operational costs and outputs within and among A.T.L.'s, it is possible to develop attainable standards of efficiency for given ranges of effectiveness on the basis of these correlations.

METHOD VII(b) - The efficiency of routine operations can be measured against standard data when standard units of work are produced. Time standards for routine operations which are performed to accomplish essential events in library services can be developed for each routine operation through group attainment programs or other work sampling studies. Group efficiency can be measured against the standard and expressed as an index of staff utilization.

CRITERION VIII

The effectiveness of a given operation is a function of the probability that essential events occur due to the outputs of that operation.

> METHOD VIII(a) - The function in Criterion VIII can be determined by the relationship or correlations between certain event probabilities and the outputs of operations.

CRITERION IX

The effectiveness of a given operation is a function of its output's contribution to the total value of the library's services or products.

> METHOD IX(a) - The function in Criterion IX can be determined by analysis of the value or utility of each operation's output in adding utility to various services and products.

As in the case of the "existing" criteria, we are interested in having the opinions of the administrators of the libraries visited with regard to the "candidate" criteria and, of course, the methods being proposed for their implementation. Therefore, the administrators were asked their opinions according to the same four factors referred to in the prior case, that is: are the statements sound, and do they appear to constitute a basis for developing standards, for measuring efficiency and for measuring effectiveness?

The opinions expressed by the library administrators were based in part upon data which we collected during the library visits. But in all cases subjective and empirical judgments were required. The data collected were in support of Criteria III, IV, V, VI, VII, VIII and IX. These data were collected when needed to demonstrate the meanings of the criteria to the librarians participating.

These data will not be presented in this chapter due to their large volume and complexity, but are available if desired. The data were not collected to be published as support for the criteria, but rather to aid the librarians in forming an opinion as to the usefulness of the criteria as a basis for measuring library efficiency and effectiveness. Some of the data will be used in Chapter VIII to demonstrate the reliability of the kinds of measurements taken.

All of the candidate criteria were considered as being valid statements by most of the librarians queried. The usefulness of the criteria, however, will depend upon the particular library and the methods of implementation. Chapter VIII will discuss the reliability of the methods and will discuss the feasibility of using the methods for developing standards and/or measuring efficiency and effectiveness at different types of libraries.

With reference to the methods proposed for implementing the candidate criteria, the library administrators were asked if, in their opinions, the methods appear to constitute a sound basis for measuring iciency and/or effectiveness and for developing standards. They were not asked their opinions as to whether or not the methods are reliable, for this remained to be determined by the contractor. The reliability of the methods will be considered in Chapter VIII.

The methods supported by most librarians queried as being useful for development of standards or valid for measurement of efficiency or effectiveness are III(a), III(b), IV(a), VI(a), VII(a), VII(b), VIII(a) and IX(a). These methods will be described in detail in Chapters IV, V, VI and VII. Certain other methods were judged as promising, but were not considered adequately developed for determining standards or for measurement of performance at the stage of their development as presented in the Phase II report. Methods III - IV and VI - IX will be combined where possible in the discussions of the remainder of this report in order to reduce the number of methods and to bring them together to form tailored techniques for measurement of library efficiency and/or effectiveness.

Methods III(a), IV(a) and VIII(a) are combined to form a technique which we shall refer to as SCORE Analysis, that is, Service COmponents Reliability and Efficiency Analysis. The Service comprises a set of operations, equipment and materials organized to meet a definable user requirement, whereas the COmponents of the service are the individual operations, equipment and materials which are necessary to provide the service. The Reliability of the components is derived from the effect they have upon the probability of meeting the objectives of the service. The Efficiency of the components can be expressed in terms of their cost and effectiveness probability (reliability).

SCORE Analysis determines the extent to which the library administrator manages his resources to provide the combination of services and products which gives optimum support to the library mission, goals and objectives (see Criterion III). SCORE Analysis makes this determination by [Method III(a)] utilizing a "systems approach" to quantify costs and effectiveness through systems (services) simulation models.*

SCORE Analysis determines the probabilities of occurrence of all events essential to satisfying defined service objectives (see Criterion IV). It makes this determination by measuring [Method IV(a)], for a population of needs, that percentage which passes each event required to accomplish the objectives of the service.

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* See cost-effectiveness analysis in Phase II glossary.

SCORE Analysis determines the probability that essential events will occur due to the outputs of operations (see Criterion VIII). This can be determined by the relationship between certain event probabilities and the outputs of operations [Method VIII(a)].

Methods III(b), VI(a) and IX(a) are combined to form a technique which we shall refer to as SCOUT Analysis, that is, Service COmponents UTility Analysis. SCOUT Analysis is intended to measure aspects of service, operations, equipment and material effectiveness which are not taken into account by SCORE Analysis. SCOUT Analysis should be used instead of SCORE Analysis for comparing effectiveness values of services when the percentage of needs met does not reflect an equitable measure of relative effectiveness of each service. That is, SCORE Analysis should be used to measure increases in effectiveness of a service and the associated costs. The SCORE Analysis effectiveness measures for different services are not necessarily comparable between services. To use an analogy a score of 100 points in a basketball game cannot be compared to a score of 100 points in a football game to reflect the same level of attainment. For example, a library administrator may be expected to judge the priority of clients needs and to provide adequate service according to priority. If this is the case, the extent to which the librarian manages his resources to provide the combination of services which give optimum support to the library mission (see Criterion III) can be measured according to the librarian's judgment of the value of each service in supporting the mission. In SCOUT Analysis, basic judgments of the relative values of each service and component (operation, equipment or materials) are recorded in such a way that mathematical equations can be used to unify them and to resolve the balance between various operations, as well as equipment and materials, which gives optimum support to the library mission [see Method III(b)]. By this method the number of needs met in each service can be weighted (leveled) to reflect the priority of services and consequently to derive equitable measures of relative value (effectiveness) of each service and component.

The effectiveness of a given library service or product is relative to the collective indifference among users, potential users, librarians and their supervisors, regarding that service and other services needed to meet their respective objectives (see Criterion VI). SCOUT Analysis determines these relationships by subjective analysis of the value or utility of each service in supporting the mission of the library and the parent organization. Weights are assigned in the analysis to reflect the collective value of each service [see Method VI(a)]. SCOUT Analysis departs from classical utility analysis in that the latter requires the registration of the actual and/or potential user judgments of the value of a commodity, while SCOUT Analysis does not necessarily require user value judgments. However, SCOUT Analysis does require questioning the users and the potential users to determine the value of the available

services given by the library, and to determine the values of varying degrees and kinds of services in supporting the mission of the library and thus, ultimately, the mission of the parent organization.

Since a military reconnaissance scout becomes adept at estimating the numbers and strength of enemy troops, it is hypothesized that by similar tactics library administrators can develop skill along the lines of estimating the value of services after exposure to the usage made of the services given (i.e., by observing, looking for clues, collecting data and interpreting). This hypothesis was supported by most librarians queried in the Phase III validation process.

The effectiveness of a given operation is a function of its output contribution to the total value of library services (see Criterion IX). SCOUT Analysis determines the value or utility of the output of each operation in adding utility to various services [see Method IX(a)].

Method VII(a) will be referred to as CORE Analysis, that is COrrelation, Regression and Effectiveness Analysis. CORE Analysis can be used to measure the efficiency of a given library operation as a function of unit cost and quality (effectiveness) of operation's outputs (see Criterion VII). Where high correlations exist between operational output cost and quantity for given quality ranges within and among A.T.L.'s, it is possible to develop attainable standards of efficiency by regression analysis for given ranges of effectiveness [see Method VII(a)].

Method VII(b) will be referred to as GAME Analysis, that is, Group Attainment and MEthods Analysis. GAME Analysis can be used to measure the efficiency of a given library operation as a function of unit cost and quality (effectiveness) of operation outputs (see Criterion VII). GAME Analysis is a systematic analysis of work to (1) eliminate unnecessary work or excessive delays; (2) arrange the remaining work in the best possible order; (3) standardize usage of proper work methods, and (4) develop time standards for the work performed to accomplish essential events in library services. Group efficiency can be measured against the standard and expressed as an index of staff utilization as in the group attainment program technique (GAP).*

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* See GAP and Methods Study in Appendix A, Phase II Report.

IV. SCORE ANALYSIS--DETAILED DESCRIPTION*

The SCORE Analysis technique will be described in detail in this chapter for a simplified sample case. The case at point will be an analysis of a library search service. In this case the user requests information on a given subject from a reference librarian (this wil' be referred to as case IIIa). A systems model simulating this service is described in Figure 1. Specific case models such as this one can be developed for each library service case and are based on the generalized models in Chapter VII of Phase II. For purposes of simplicity in this description we shall assume that the library performs only search service (case IIIa) and circulation service. We shall also assume that the effectiveness of circulation service is 100% and that the library is specialized in serving research and development only.

The effectiveness of the library and search service (case IIIa) would then be the product of probabilities 2, 3, 4, 6 and 7, assuming all the needs were within the mission.

TASK 1

The first task will be to collect statistics on the number of needs processed for a given period of time, e.g., 1 month, and to record for each need the data required in the Operator's SCORE Analysis Data Sheet (Form 1).

From these data the percentage of needs which passed each event and the labor time can be calculated for the month. If for the month of January of year "A" 200 of 200 total needs were communicated adequately to initiate a search, the percentage of needs passing event 2 is $\frac{200}{200} \times 100 = 100\%$. During the same month, if 200 of the 200 total needs entering event 3 were considered within the mission, the percentage of needs passing event 3 is $\frac{200}{200} \times 100 = 100\%$. If 180 of the 200 needs passed event 4, the percentage of needs passing event 4 = $\frac{180}{200} \times 100 = 90\%$. This procedure can be continued to determine the percentage of needs which pass each event. Figure 2 shows data for the percentage of needs met by each event and cost data for certain direct labor activities during January for the hypothetical special library.

The same data are collected for several other periods of time, e.g., for February and March of year "A", and the percentage of needs passing each event is computed and recorded in Figures 3 and 4.

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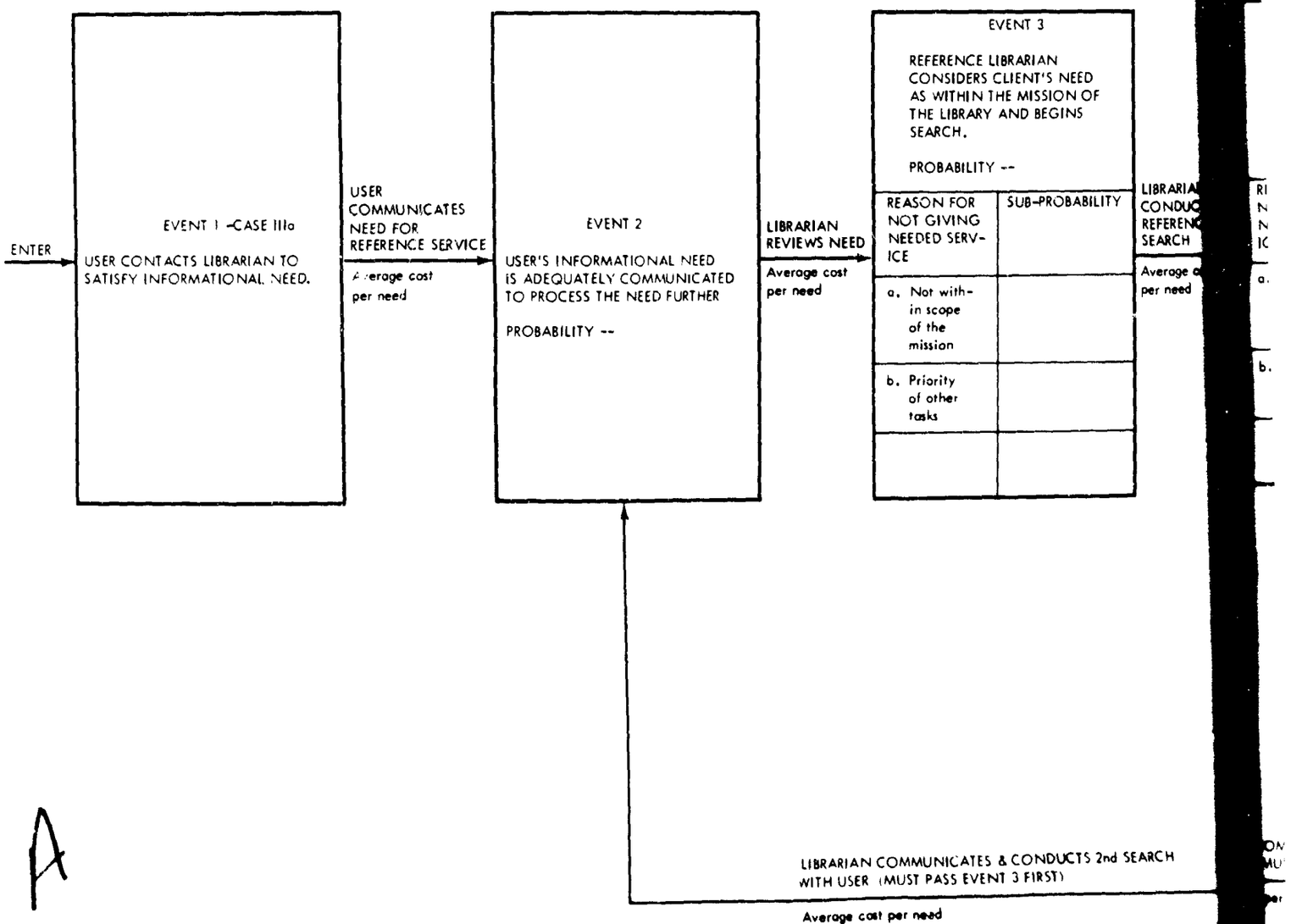
* SCORE Analysis is discussed in principle in Chapter VII of the Phase II report under Cost-Effectiveness Analysis on pp.65 through 73.

SEARCH SERVICE (LIBRA

EQUIVOCAL EXPRESSIO

CASE I



A

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

EVENT 5

A BIBLIOGRAPHY IS PROVIDED AND USER REVIEWS BIBLIOGRAPHY, AND IDENTIFIES SOME CANDIDATE DOCUMENTS FOR RETRIEVAL.

PROBABILITY --

BIBLIOGRAPHY IS PREPARED

Average cost per need

LIBRARIAN AND OR USER RETRIEVES OR ORDERS SOME RELEVANT DOCUMENTS

Average cost per need

EVENT 3

REFERENCE LIBRARIAN CONSIDERS CLIENT'S NEED AS WITHIN THE MISSION OF THE LIBRARY AND BEGINS SEARCH.

PROBABILITY --

REASON FOR NOT GIVING NEEDED SERVICE	SUB-PROBABILITY
a. Not within scope of the mission	
b. Priority of other tasks	

LIBRARIAN CONDUCTS REFERENCE SEARCH

Average cost per need

EVENT 4 - CASE IIIa

SOME CANDIDATE DOCUMENTS ARE IDENTIFIED OR LOCATED BY THE LIBRARIAN.

PROBABILITY --

IDENTIFIED	NO. ID.	SUB-PROBABILITY
a. In card catalog	1 ·	
	2 ·	
	3 ·	
	4 ·	
	5 ·	
	6 ·	
	7 ·	
	8 ·	
	9 ·	
	10 ·	
b. In other ref. sources		
c. By information retrieval system		
d. In another library		

LIBRARIAN AND OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS

Average cost per need

EVENT 6

SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.

PROBABILITY --

ORDERED FROM	SUB-PROBABILITY
a. Stacks	
b. Inter-library loan	
c. Vendor	

CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE

Average cost per need

EVEN

SOME OF DOCUME RELEVAN

PROBABIL

RETRIEVE
1 ·
2 ·
3 ·
4 ·
5 ·
6 ·
7 ·
8 ·
9 ·
10 ·

INDIRECT FACTORS

FACTOR	NO.	COST
No. of documents in collection per subject class requested		
Avg. no. of index terms per title indexed		

OMMUNICATES & CONDUCTS 2nd SEARCH
MUST PASS EVENT 3 FIRST

er need

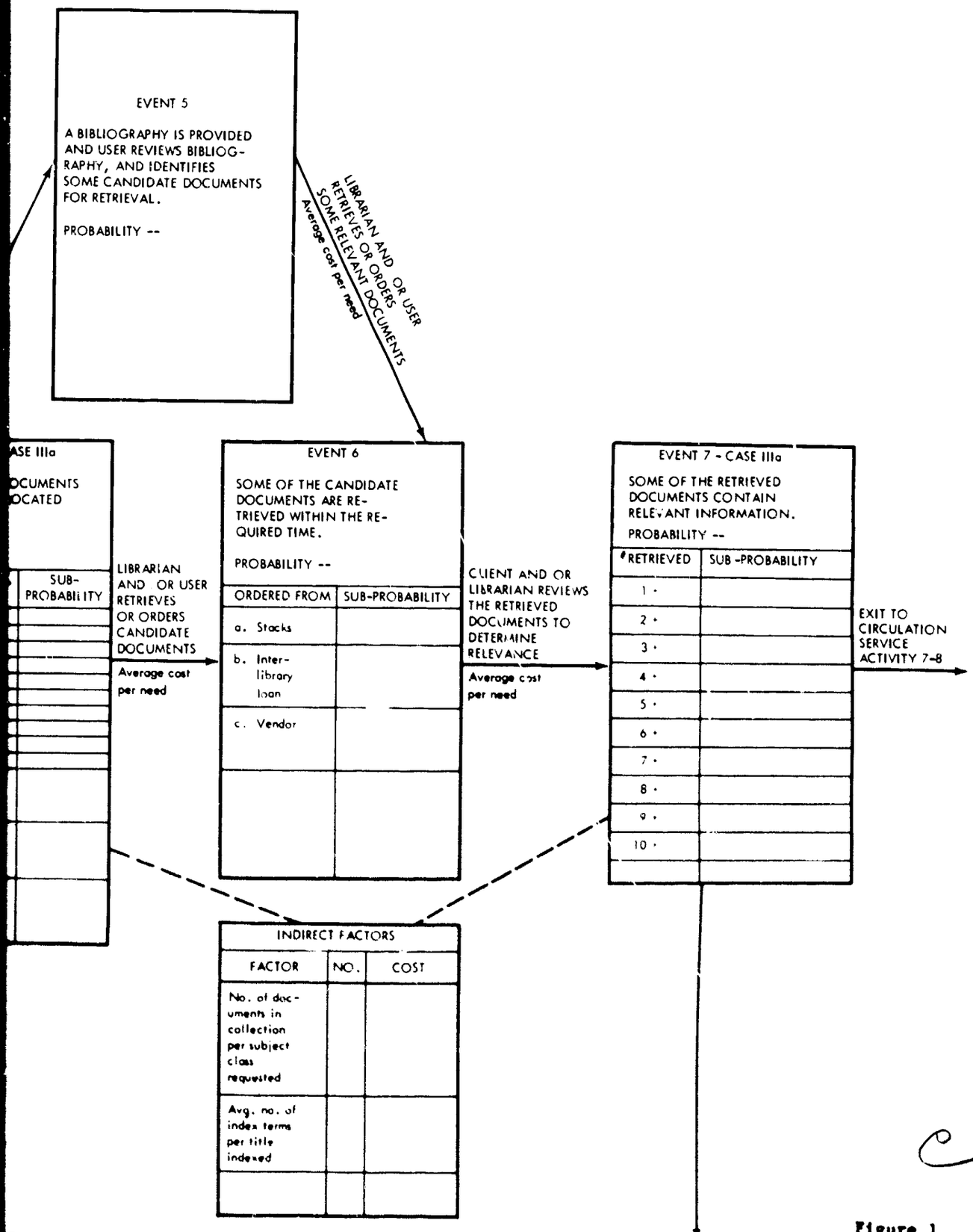
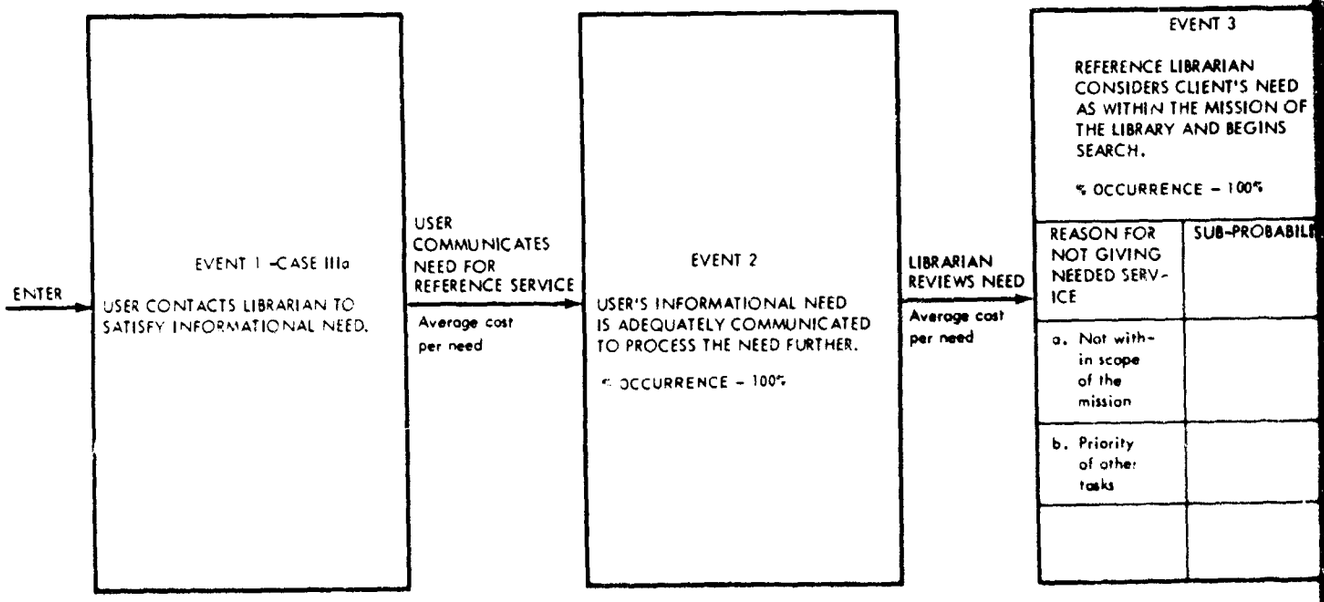

EVENT 5
A BIBLIOGRAPHY IS PROVIDED AND USER REVIEWS BIBLIOGRAPHY, AND IDENTIFIES SOME CANDIDATE DOCUMENTS FOR RETRIEVAL.
PROBABILITY --
LIBRARIAN AND OR USER RETRIEVES OR ORDERS SOME RELEVANT DOCUMENTS
Average cost per need
ASE IIIa
OCUMENTS OCATED
SUB-PROBABILITY
LIBRARIAN AND OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
PROBABILITY --
ORDERED FROM
SUB-PROBABILITY
a. Stacks
b. Inter-library loan
c. Vendor
CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need
EVENT 7 - CASE IIIa
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
PROBABILITY --
RETRIEVED
SUB-PROBABILITY
1 •
2 •
3 •
4 •
5 •
6 •
7 •
8 •
9 •
10 •
EXIT TO CIRCULATION SERVICE ACTIVITY 7-8
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
Avg. no. of index terms per title indexed

Figure 1

SEARCH SE

EQUIVOCA

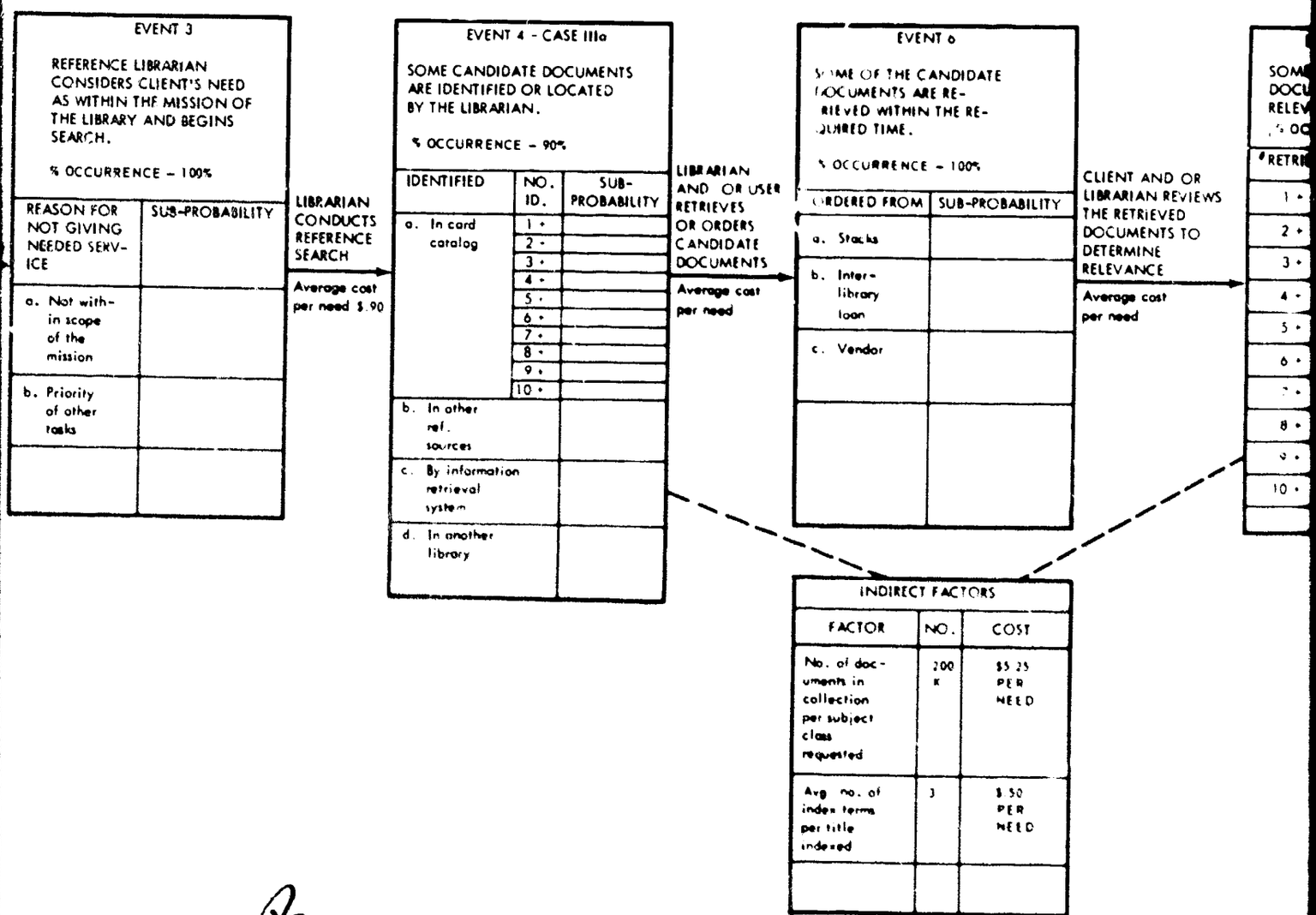


SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

JANUARY, YEAR "A"



B

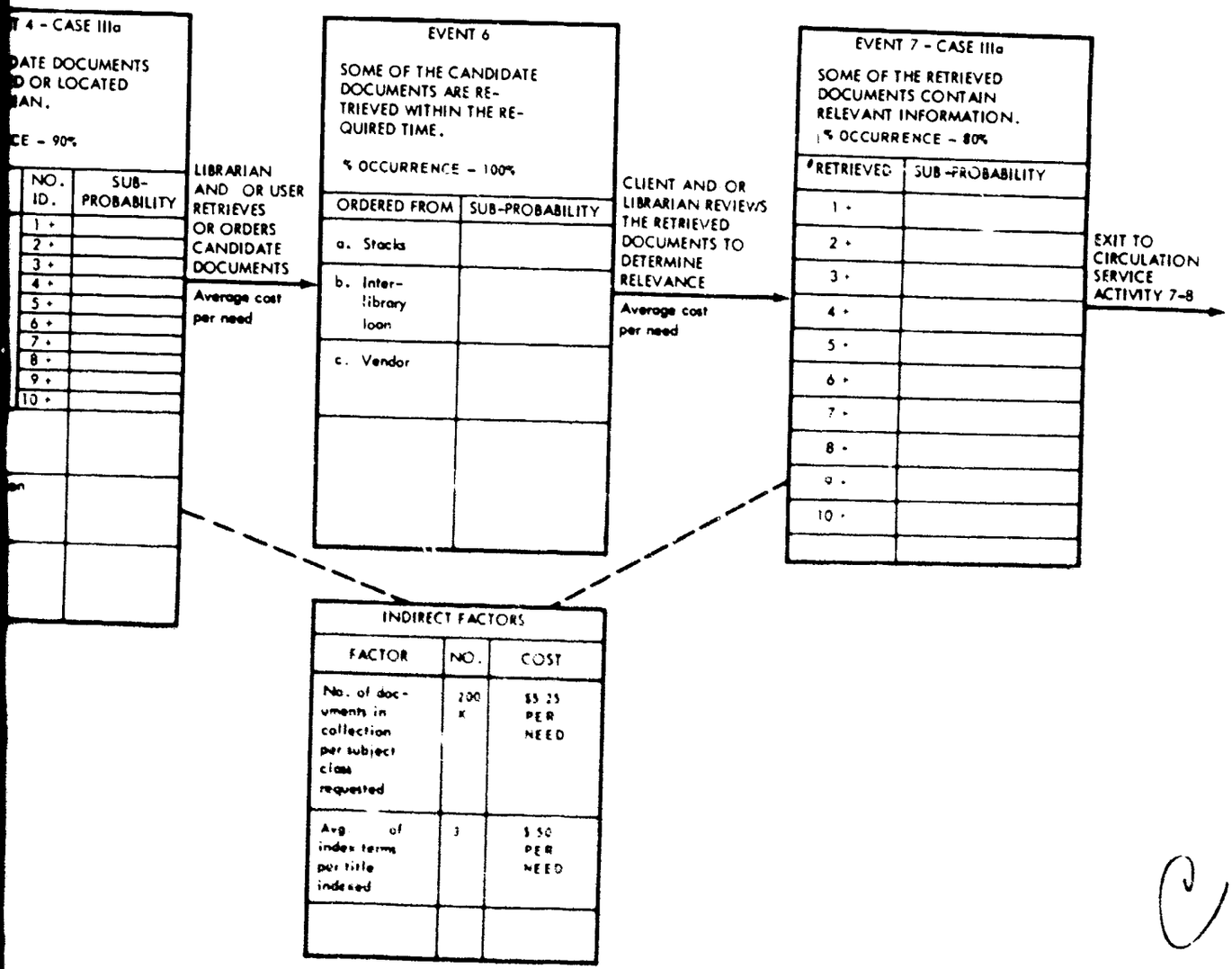
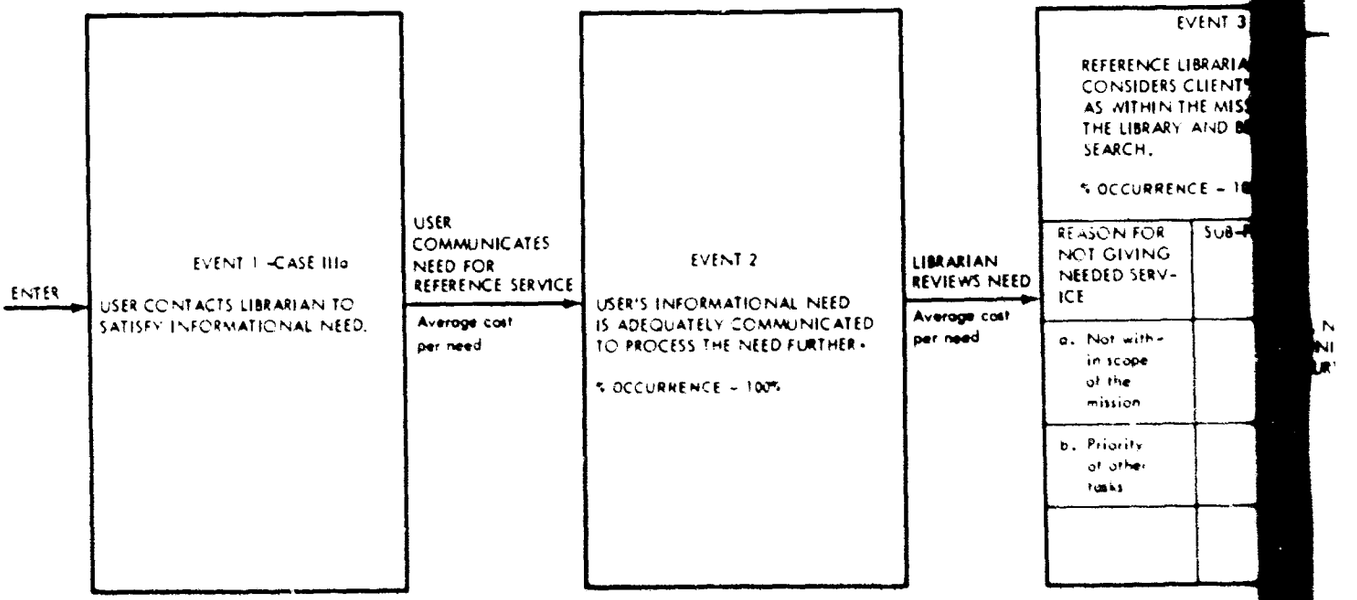

T 4 - CASE IIIa
DATE DOCUMENTS
D OR LOCATED
IAN.
CE - 90%
NO. ID.
SUB-PROBABILITY
1 +
2 +
3 +
4 +
5 +
6 +
7 +
8 +
9 +
10 +
LIBRARIAN AND OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
% OCCURRENCE - 100%
ORDERED FROM
SUB-PROBABILITY
a. Stacks
b. Inter-library loan
c. Vendor
CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need
EVENT 7 - CASE IIIa
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
% OCCURRENCE - 80%
RETRIEVED
SUB-PROBABILITY
1 +
2 +
3 +
4 +
5 +
6 +
7 +
8 +
9 +
10 +
EXIT TO CIRCULATION SERVICE ACTIVITY 7-8
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
200 K
$5.25 PER NEED
Avg. of index terms per title indexed
3
$.50 PER NEED

Figure 2

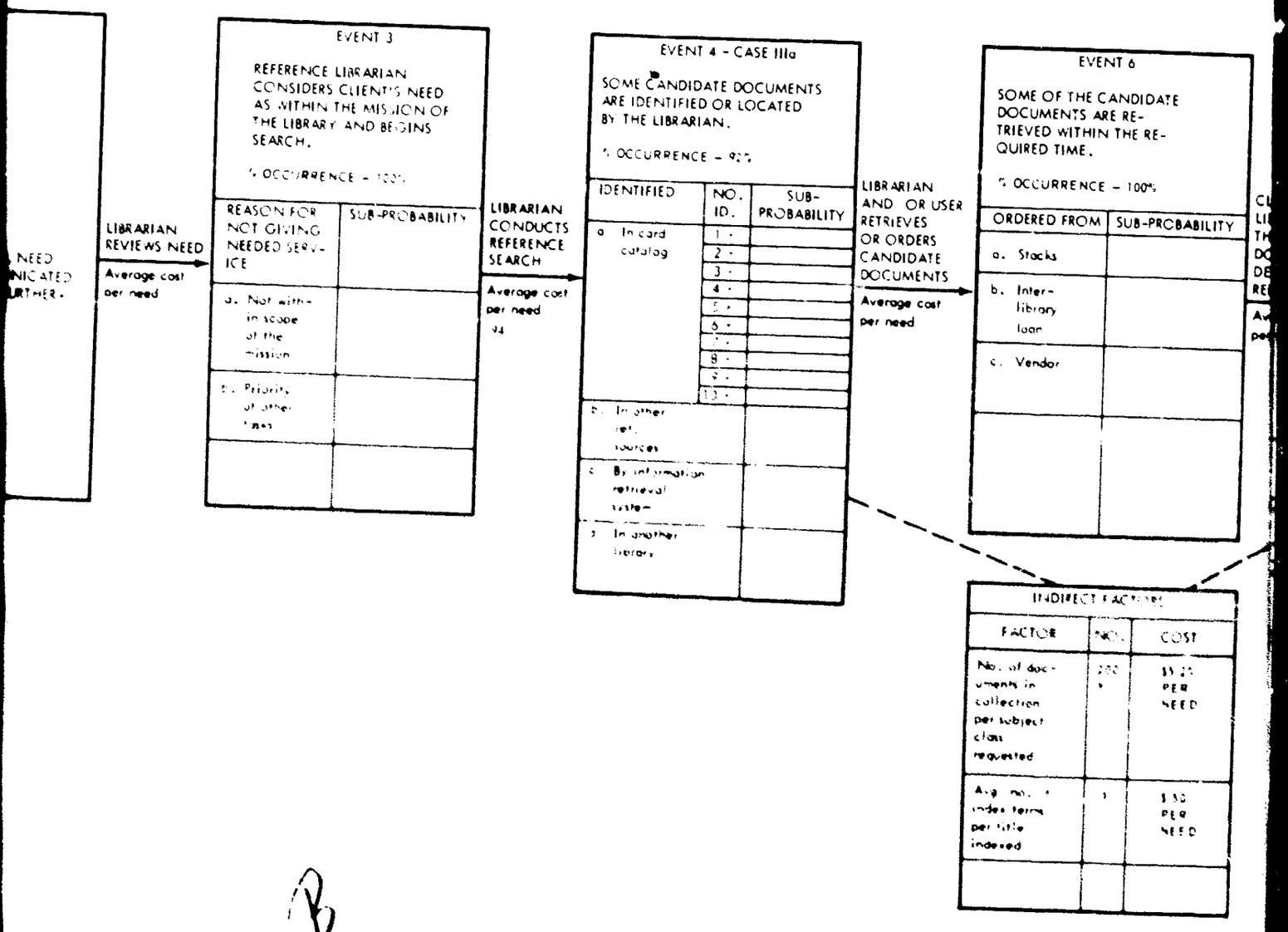

ENTER
EVENT 1 -CASE IIIa
USER CONTACTS LIBRARIAN TO SATISFY INFORMATIONAL NEED.
USER COMMUNICATES NEED FOR REFERENCE SERVICE
Average cost per need
EVENT 2
USER'S INFORMATIONAL NEED IS ADEQUATELY COMMUNICATED TO PROCESS THE NEED FURTHER.
% OCCURRENCE - 100%
LIBRARIAN REVIEWS NEED
Average cost per need
EVENT 3
REFERENCE LIBRARIA
CONSIDERS CLIENT'
AS WITHIN THE MISS
THE LIBRARY AND B
SEARCH.
% OCCURRENCE - 1
REASON FOR NOT GIVING NEEDED SERV-ICE
SUB-
a. Not with-in scope of the mission
b. Priority of other tasks

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

FEBRUARY YEAR "A"



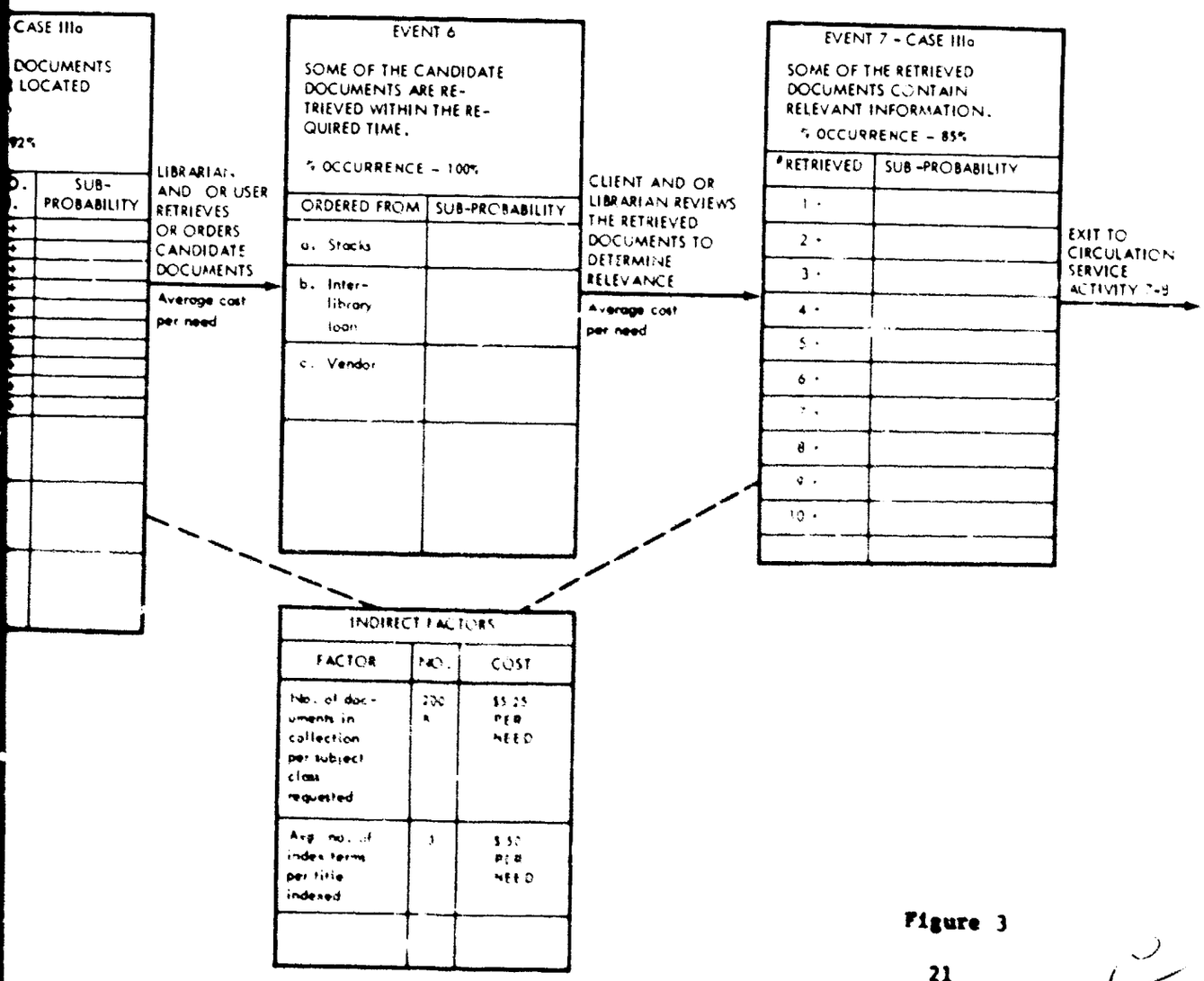
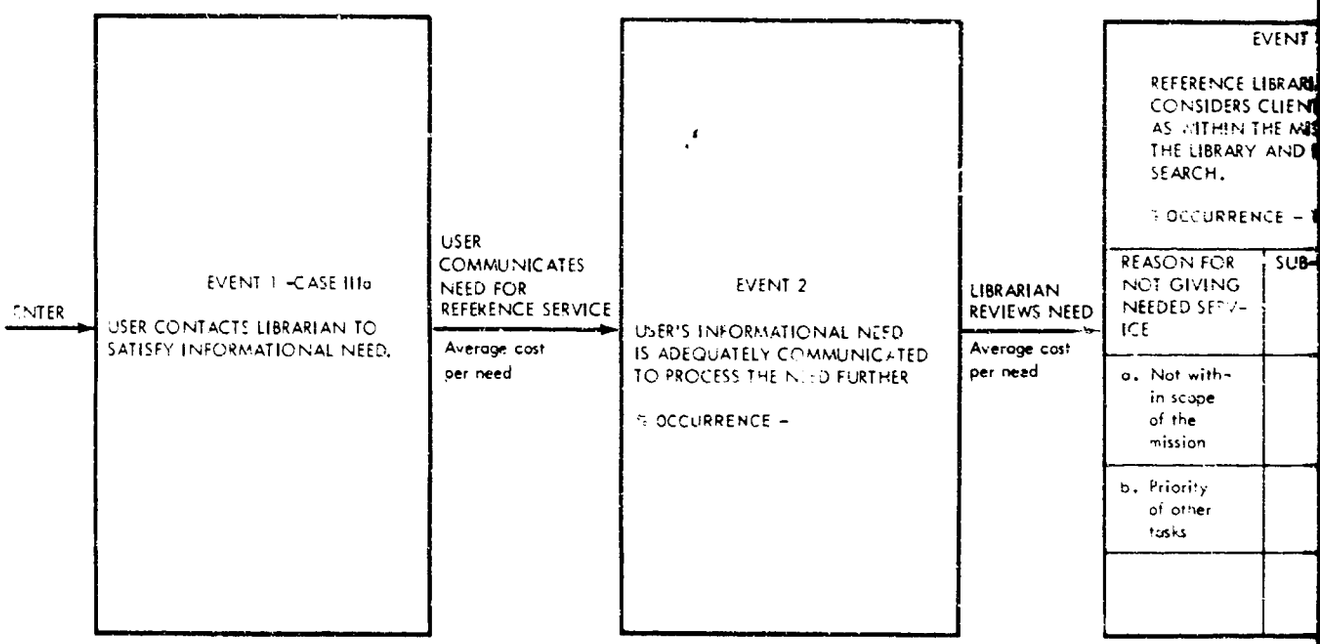

CASE 111a
DOCUMENTS
LOCATED
92%
SUB-
PROBABILITY
LIBRARIAN AND OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
% OCCURRENCE - 100%
ORDERED FROM
SUB-PROBABILITY
a. Stacks
b. Inter-library loan
c. Vendor
CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need
EVENT 7 - CASE 111a
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
% OCCURRENCE - 85%
RETRIEVED
SUB-PROBABILITY
1 •
2 •
3 •
4 •
5 •
6 •
7 •
8 •
9 •
10 •
EXIT TO CIRCULATION SERVICE ACTIVITY 7-9
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
200
$5.25 PER NEED
Avg no. of index terms per title indexed
3
$.50 PER NEED

Figure 3

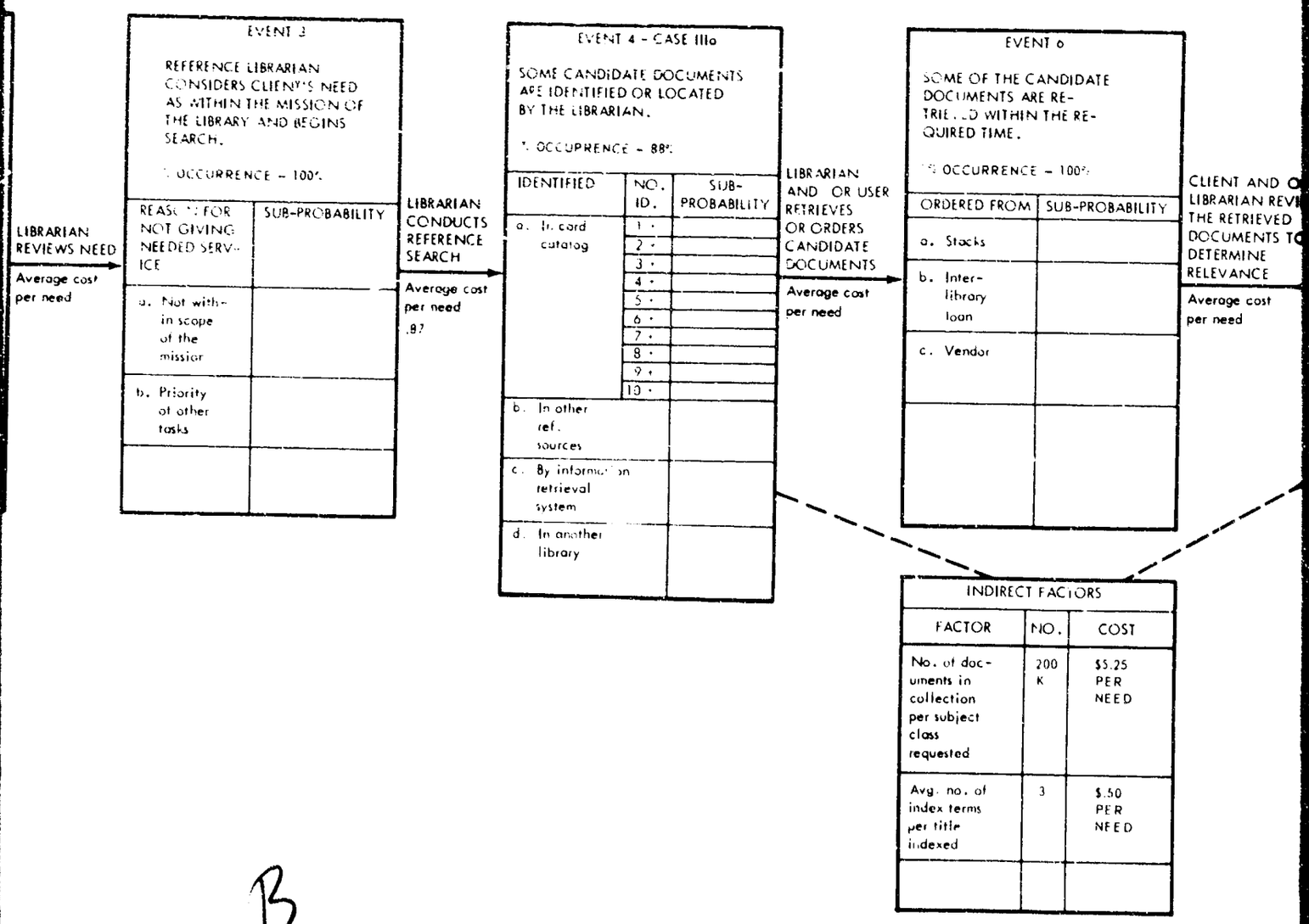

ENTER
EVENT 1 -CASE IIIa
USER CONTACTS LIBRARIAN TO SATISFY INFORMATIONAL NEED.
USER COMMUNICATES NEED FOR REFERENCE SERVICE
Average cost per need
EVENT 2
USER'S INFORMATIONAL NEED IS ADEQUATELY COMMUNICATED TO PROCESS THE NEED FURTHER
% OCCURRENCE –
LIBRARIAN REVIEWS NEED
Average cost per need
EVENT
REFERENCE LIBRARI
CONSIDERS CLIENT
AS WITHIN THE MI
THE LIBRARY AND
SEARCH.
% OCCURRENCE –
REASON FOR NOT GIVING NEEDED SERV-ICE
SUB-
a. Not within scope of the mission
b. Priority of other tasks

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

MARCH YEAR "A"



B

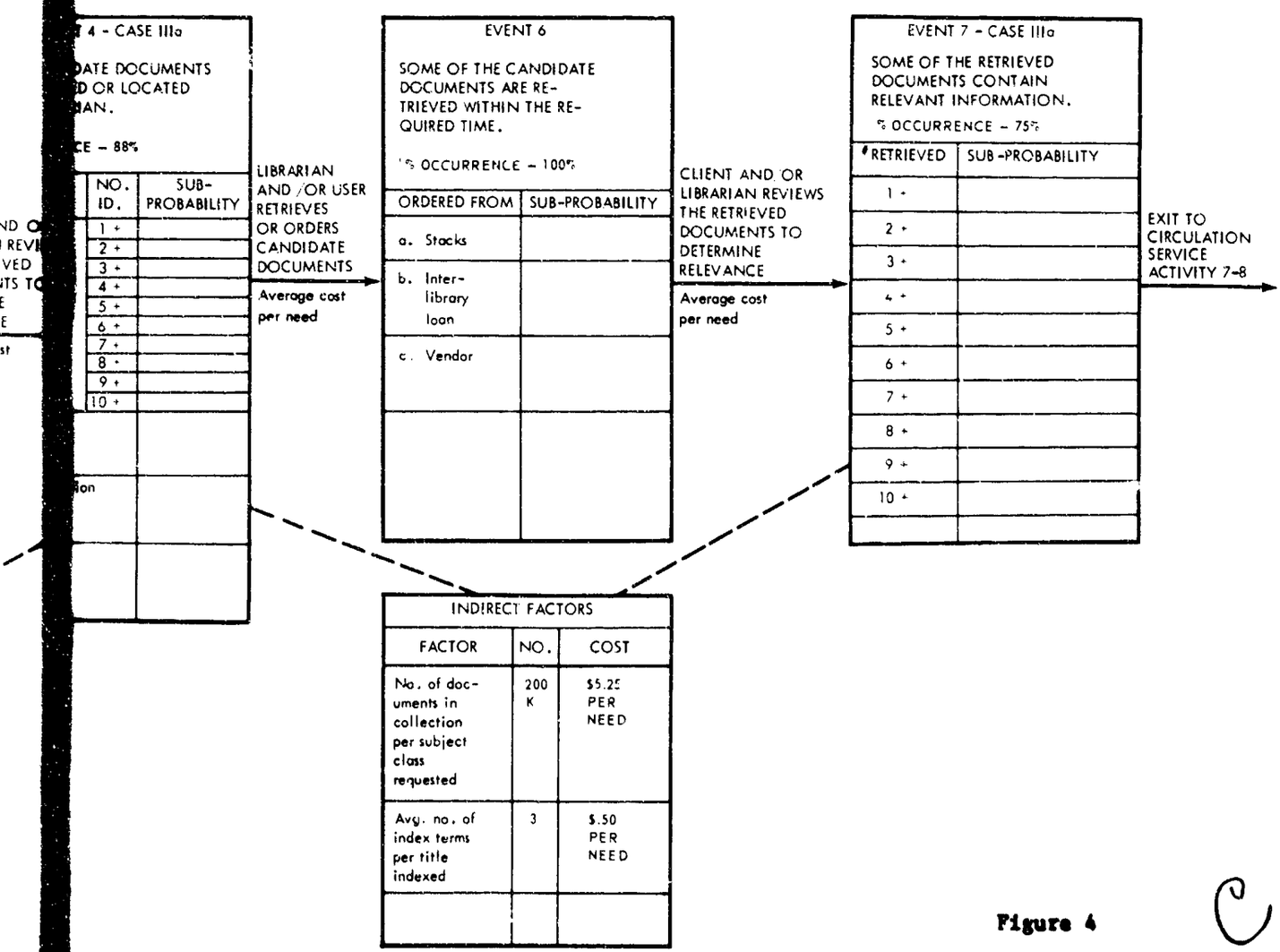

4 - CASE IIIa
ATE DOCUMENTS
D OR LOCATED
AN.
E - 88%
NO. ID.
SUB-PROBABILITY
1 +
2 +
3 +
4 +
5 +
6 +
7 +
8 +
9 +
10 +
LIBRARIAN AND /OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
% OCCURRENCE - 100%
ORDERED FROM
SUB-PROBABILITY
a. Stacks
b. Inter-library loan
c. Vendor
CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need
EVENT 7 - CASE IIIa
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
% OCCURRENCE - 75%
RETRIEVED
SUB-PROBABILITY
1 +
2 +
3 +
4 +
5 +
6 +
7 +
8 +
9 +
10 +
EXIT TO CIRCULATION SERVICE ACTIVITY 7-8
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
200 K
$5.25 PER NEED
Avg. no. of index terms per title indexed
3
$.50 PER NEED

Figure 4

OPERATOR'S SCORE ANALYSIS DATA SHEET

1. Did the user communicate his need adequately to process the need further, that is, did the user give the librarian enough information to determine if the need was within the mission and to begin a search?

_____

_____

2. Did the librarian begin a search? /__/ Yes /__/ No

   (a) If No in 2, why not?

_____

_____

3. Were any candidate documents identified by the librarian? /__/Yes /__/No

   (a) How many identified?_____

   (b) Located through what reference source? _____

_____

_____

4. Were any of the candidate documents retrieved within the required time? /__/ Yes /__/ No

   (a) From what source? _____ _____

_____

_____

   (b) How many? _____

5. Did any of the retrieved documents contain relevant information?/__/Yes /__/ No

   How many? _____

6. How much time was spent:

   (a) In communication? _____

   (b) In reviewing the need to determine if a search will be conducted?

_____

   (c) In 1st search? _____

   (d) In providing a bibliography? _____

   (e) In recommunication and 2nd search? _____

   (f) In retrieval? _____

   (g) In reviewing the document to determine relevance? _____

FORM 1

TASK 2

Having the percentage of occurrence of each event for 3 periods, we can now compute the probability of event occurrence. Since event 4 percentages (90%, 92% and 88%, respectively, for January, February and March) do not range significantly, we shall consider the average of the 3 percentages as the probability of event 4 occurrence under existing operating conditions. The probability of event 4 occurrence is, therefore, .90.

The reliability of this measure and other measures is discussed on p. 83 through 87 of this report.

TASK 3

The next task is to compute the average cost per need* for the period. The cost per need for activities 3-4 recorded in Figures 2, 3 and 4 were $.90, $.94 and $.87, respectively, for January, February and March. The average $.903 is a reliable measure of the cost per need for the existing direct labor cost of conducting searches, since the range in average cost for the 3 periods is small.

TASK 4

Task 4 requires changes in operational procedures. Figure 5 presents the effectiveness probabilities and the cost per need measures for the existing service under existing operating conditions. The only events which prevent 100% effectiveness in meeting the objective of providing some relevant documents for each need are events 4 and 7.** At this point changes in the existing operational practices or policies may be made to attempt to increase either or both of these probabilities.

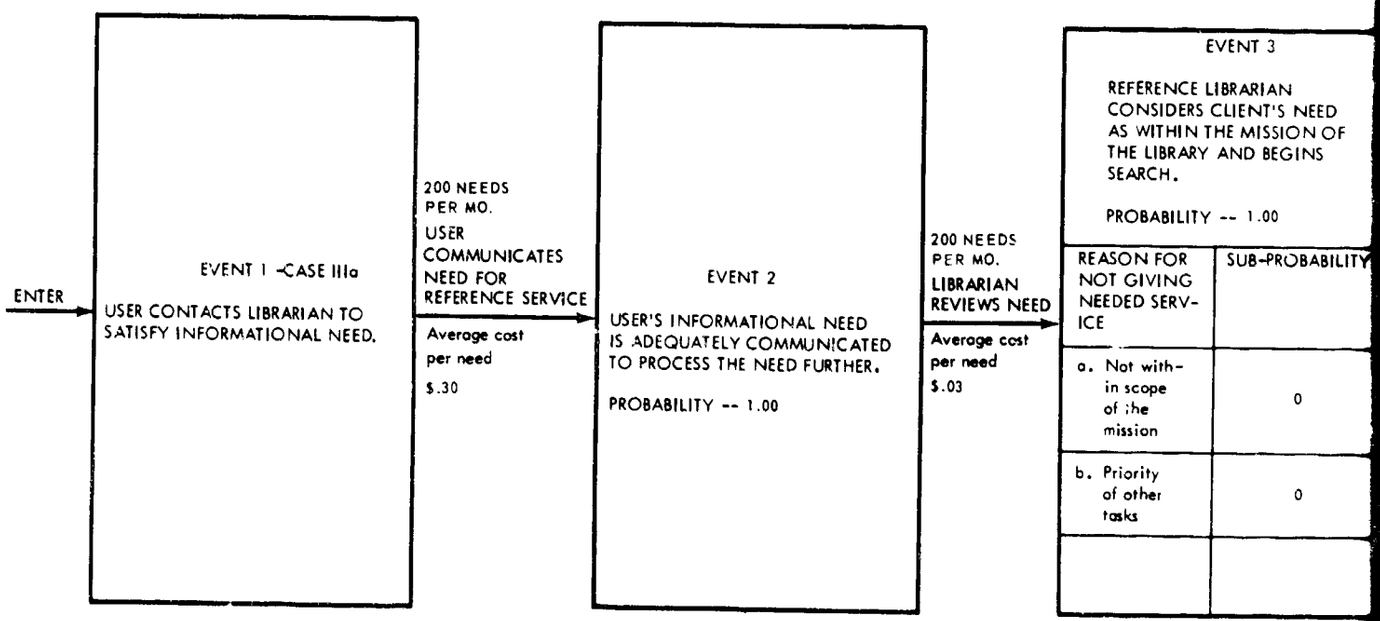
It is not the primary purpose of this contract to develop criteria to direct library administrators in their decisions for making changes in operational policy or procedures; instead the primary purpose of this contract and SCORE Analysis is to provide criteria and methods for measuring operational performance.

The changes made in the attempt to improve effectiveness should be based on empirical criteria in the minds of the administrators themselves. Type 5 approach discussed in the Phase II report may help to formalize these criteria and enable the administrator to manipulate the variables more objectively. By whatever means employed, we will assume that management has concluded that effectiveness can probably be improved by recommunication with users when the first search failed to identify relevant

---

* Direct labor costs are derived from the time values in the Operator's SCORE Analysis Data Sheet and from the operator's wage rate.

** If event 3 probability is less than 100%, sub-probability 3a (need not within the scope of the mission) should be added to event 3 probability for computing effectiveness.

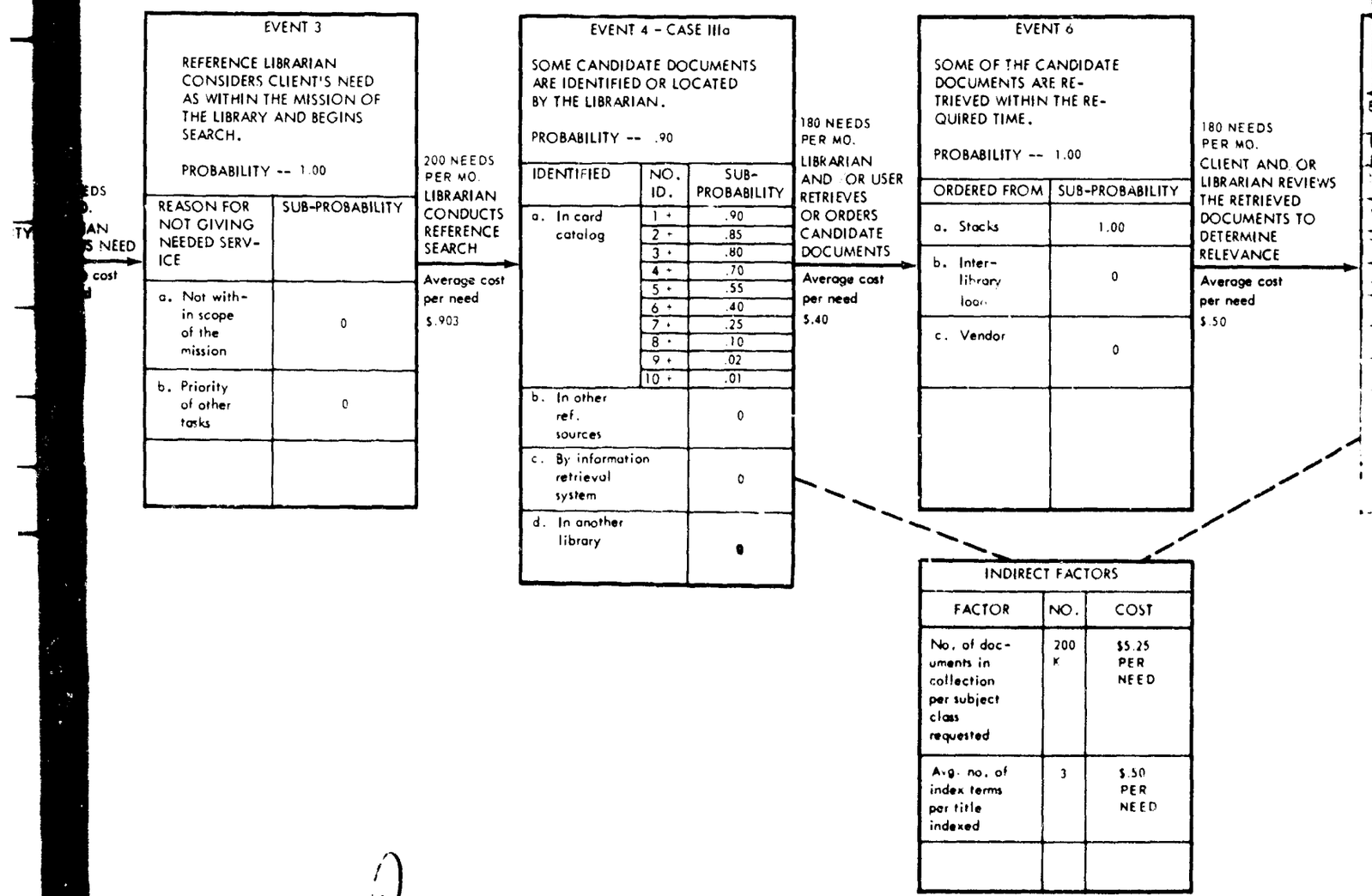

ENTER
EVENT 1 -CASE IIIa
USER CONTACTS LIBRARIAN TO SATISFY INFORMATIONAL NEED.
200 NEEDS PER MO.
USER COMMUNICATES NEED FOR REFERENCE SERVICE
Average cost per need
$.30
EVENT 2
USER'S INFORMATIONAL NEED IS ADEQUATELY COMMUNICATED TO PROCESS THE NEED FURTHER.
PROBABILITY -- 1.00
200 NEEDS PER MO.
LIBRARIAN REVIEWS NEED
Average cost per need
$.03
EVENT 3
REFERENCE LIBRARIAN CONSIDERS CLIENT'S NEED AS WITHIN THE MISSION OF THE LIBRARY AND BEGINS SEARCH.
PROBABILITY -- 1.00
REASON FOR NOT GIVING NEEDED SERVICE
SUB-PROBABILITY
a. Not within scope of the mission
0
b. Priority of other tasks
0

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

JANUARY – MARCH, YEAR "A"



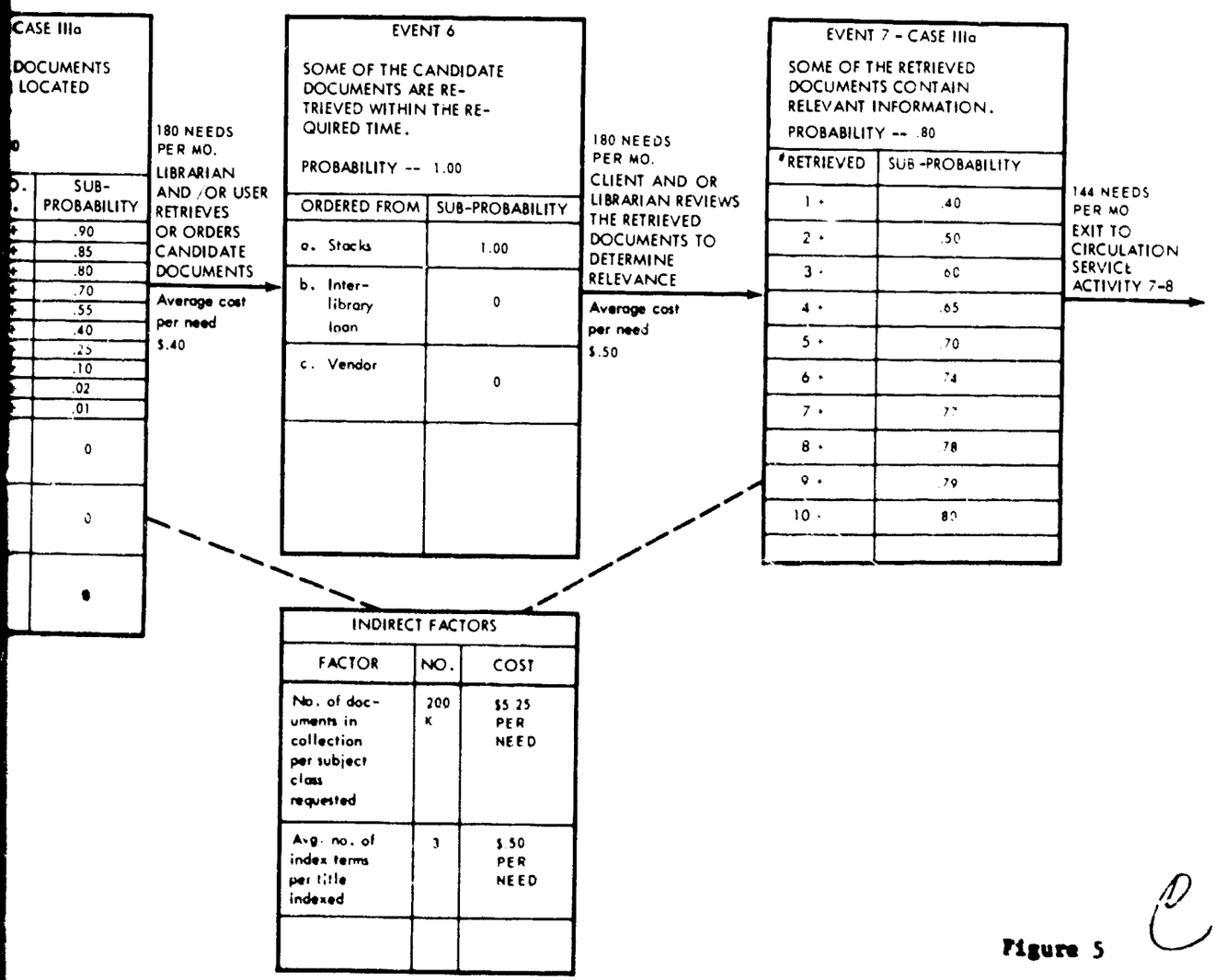
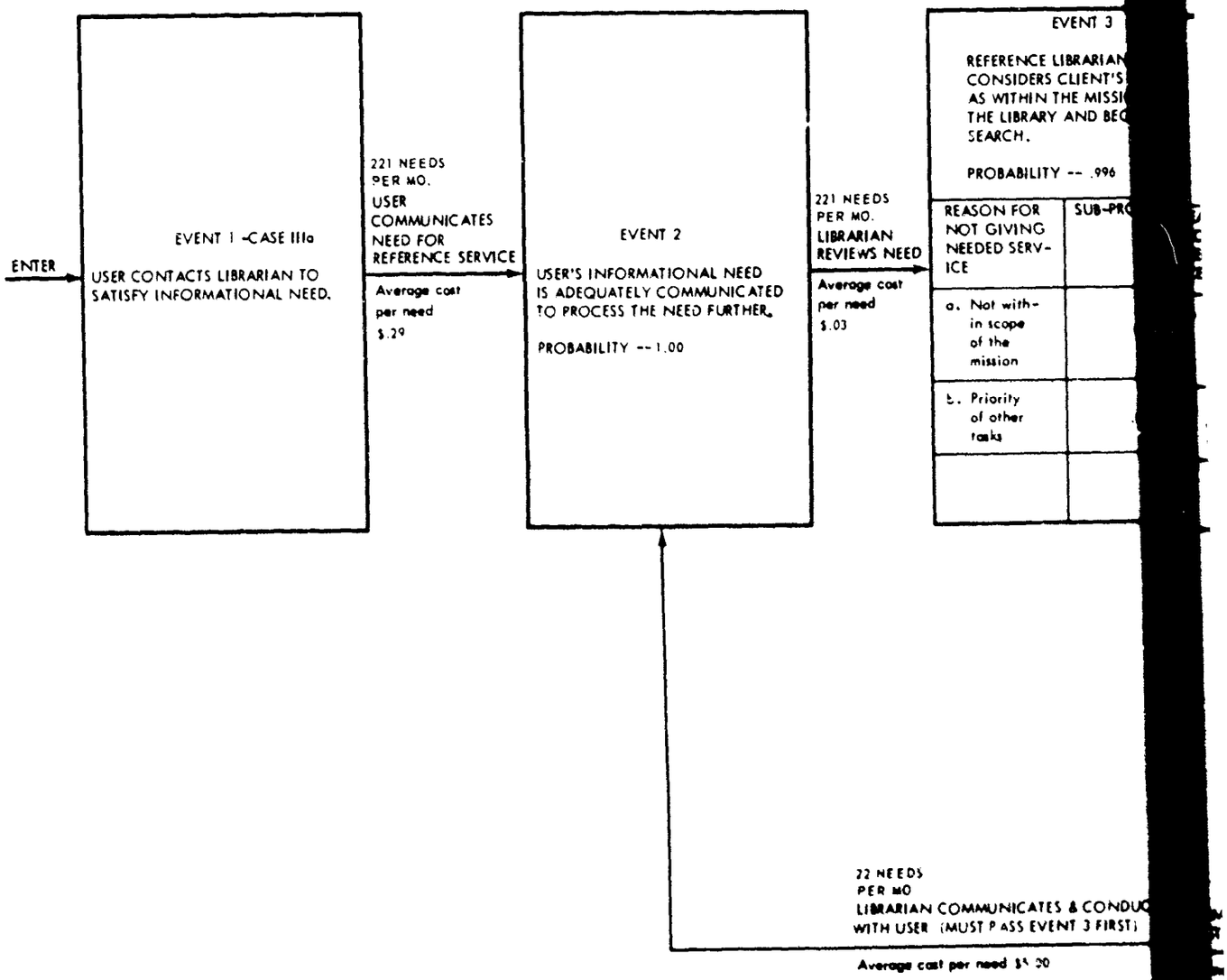

CASE IIIa
DOCUMENTS LOCATED
SUB-PROBABILITY
.90
.85
.80
.70
.55
.40
.25
.10
.02
.01
0
0
0
180 NEEDS PER MO.
LIBRARIAN AND /OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need
$.40
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
PROBABILITY -- 1.00
ORDERED FROM
SUB-PROBABILITY
a. Stacks
1.00
b. Inter-library loan
0
c. Vendor
0
180 NEEDS PER MO.
CLIENT AND OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need
$.50
EVENT 7 - CASE IIIa
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
PROBABILITY -- .80
#RETRIEVED
SUB-PROBABILITY
1 - .40
2 - .50
3 - .60
4 - .65
5 - .70
6 - .74
7 - .77
8 - .78
9 - .79
10 - .80
144 NEEDS PER MO
EXIT TO CIRCULATION SERVICE ACTIVITY 7-8
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
200 K
$5.25 PER NEED
Avg. no. of index terms per title indexed
3
$.50 PER NEED

Figure 5

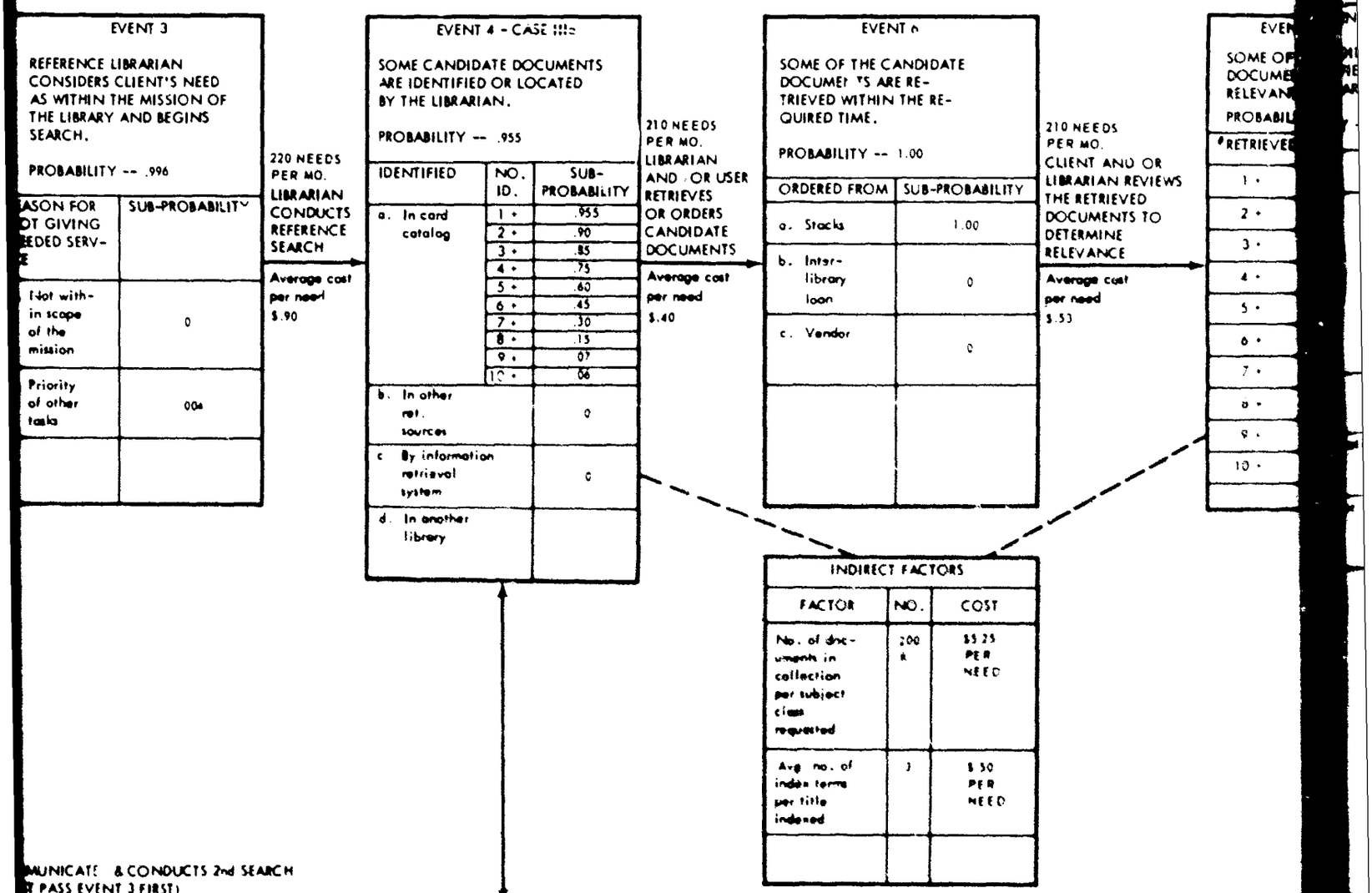

ENTER
EVENT 1 -CASE IIIa
USER CONTACTS LIBRARIAN TO SATISFY INFORMATIONAL NEED.
221 NEEDS PER MO.
USER COMMUNICATES NEED FOR REFERENCE SERVICE
Average cost per need
$.29
EVENT 2
USER'S INFORMATIONAL NEED IS ADEQUATELY COMMUNICATED TO PROCESS THE NEED FURTHER.
PROBABILITY -- 1.00
221 NEEDS PER MO.
LIBRARIAN REVIEWS NEED
Average cost per need
$.03
EVENT 3
REFERENCE LIBRARIAN
CONSIDERS CLIENT'S
AS WITHIN THE MISSI
THE LIBRARY AND BE
SEARCH.
PROBABILITY -- .996
REASON FOR NOT GIVING NEEDED SERV-ICE
SUB-PR
a. Not with-in scope of the mission
b. Priority of other tasks
22 NEEDS PER MO
LIBRARIAN COMMUNICATES & CONDU
WITH USER (MUST PASS EVENT 3 FIRST)
Average cost per need $

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

MAY - JULY, YEAR "A"



B

ARCH)

NEED

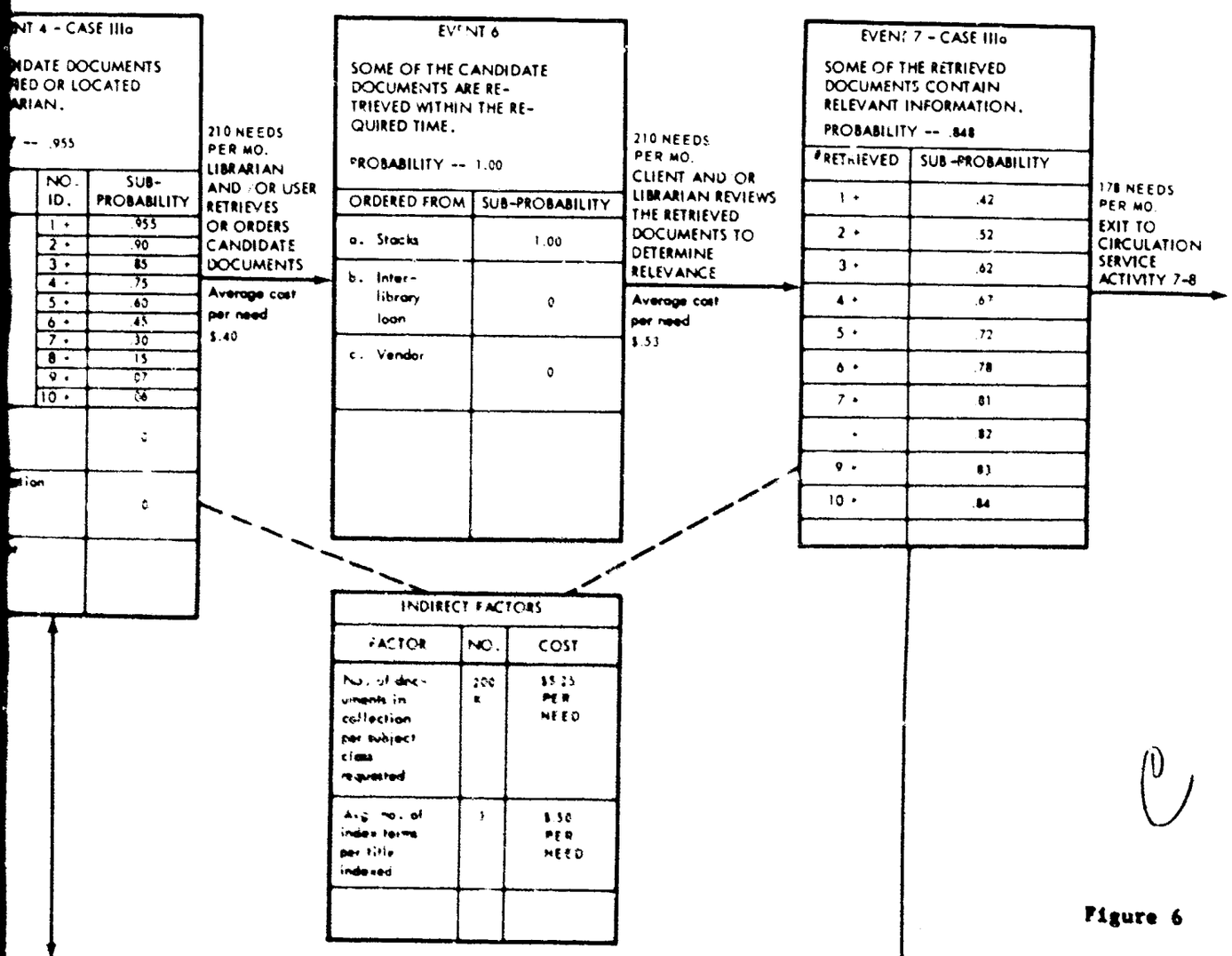


Figure 6

documents and by conducting a second search. Assume that additional man-hours are assigned to reference activities and a policy is written that for all needs which are not provided with some clearly relevant documents, a second communication step is begun. This activity will have as its objective (1) a better definition of the need, (2) a more exhaustive list of descriptors and (3) more specific descriptors and their synonyms.

The new policies at the library are implemented and, after a period of adjustment to the new operational practices, data for costs and effectiveness assessment should again be collected.

TASK 5

Task 5 is a cost-effectiveness analysis for alternate operational procedures. Measures of percent of occurrence of events and cost data are compiled for the new procedures. Let us assume that in May, June and July of year "A" the recommunications and a second search are measured and found to take an average of 50 minutes for each need which was not provided with some relevant documents after the first search, and the probabilities of events 4 and 7 increased to .955 and .848, respectively. All other costs and probabilities remained approximately the same as reflected in Figure 6.

From the data in Figures 5 and 6 we can compute the total direct labor cost and effectiveness of the search service offered. The cost for January-March is

($.30)(200 needs) + ($.03)(200 needs) + ($.903)(200 needs)
+ ($.40)(180 needs) + ($.50)(180 needs) + k =
$60.00 + $6.00 + $180.60 + $72.00 + $90.00 + k =
$408.60 + k

where: k = (constant indirect costs + overhead).* The effectiveness for January-March is the product of the event probabilities

(1.00)(1.00)(.90)(1.00)(.80) = .72

The total cost for direct labor for May-July is

(.29)(221) + (.03)(221) + (.90)(220) + (.40)(210) + (.53)(210)
+ (5.00)(22) + k =
$64.09 + $6.63 + $198.00 + $84.00 + $111.30 + $110.00 + k =
$574.02 + k

and the effectiveness is

(1.00)(.996)(.955)(1.00)(.848) = .807.

* k is a constant cost figure which represents costs other than those which can be derived from the operator's SCORE Analysis data sheet and wage rates. These "other" costs can be computed, but it will not be necessary to do so in SCORE Analysis if they are relatively constant costs expended primarily for long-run benefits.

We now have cost and effectiveness measures for these 2 periods. However, they are not comparable, since the number of needs met during the 2 periods vary. To have comparable figures we should divide the cost of the service by the number of needs which passed event 7, which is the objective of the service. The comparable figures are:

for January-March

$$\text{Cost} = \frac{\$408.60 + k}{144 \text{ needs}} = \frac{\$2.84 + k}{\text{need}}$$

Effectiveness = .720;

for May-July

$$\text{Cost} = \frac{\$574.02 + k}{178 \text{ needs}} = \frac{\$3.22 + k}{\text{need}}$$

Effectiveness = .807.

We can now construct a cost-effectiveness diagram of the type discussed in the Phase II report, pp. 65 and 66. The cost-effectiveness coordinate point of the operational procedures for January through March is represented by the point marked 1 and that of May through July is marked 2 (see Figure 7). An analysis of the cost-effectiveness diagram will show the change in effectiveness with respect to the change in cost, both due to the change in communications and search procedures. This relationship is mathematically represented as $\frac{\Delta E}{\Delta C}$ and is equal to $\frac{.807 - .720}{3.22 - 2.84} = \frac{.087}{.38} = .229$. In the denominator we drop k since the investment of k adds effectiveness to future needs. We shall refer to this quantity (.229) as the delta index of cost-effectiveness* for the change. Before the new policies and procedures are adopted permanently, the library administrator should compute the delta index of cost-effectiveness for all other feasible alternate solutions. One possible alternate to recommunication and a second search may be to refer all needs not met after the original search to other libraries or automated information retrieval centers such as Defense Documentation Center. Assume for the months of September, October and November of year "A" that the library did not recommunicate with users or conduct a second search when the first search was not successful, but instead requested bibliographies from selected interlibrary loan and information retrieval organizations. This new procedure resolves new probabilities and costs as reflected in Figure 8.

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* It is possible to derive a negative delta index of cost-effectiveness; if ΔE is negative when ΔC is positive, the change should not be made; if ΔC is negative when ΔE is positive, the change should be made permanent if the budget is not exceeded and if a better alternate solution is not found.

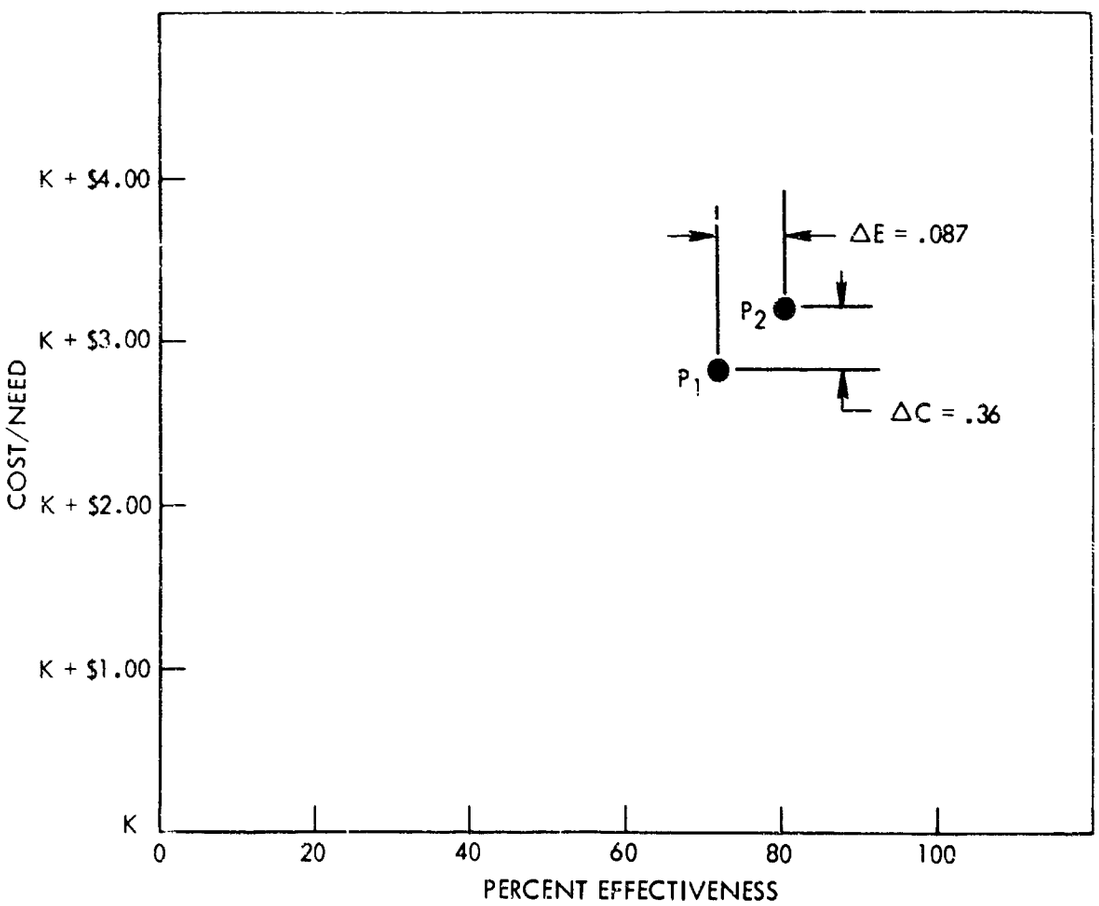
K + $4.00
K + $3.00
K + $2.00
K + $1.00
K
COST/NEED
0
20
40
60
80
100
PERCENT EFFECTIVENESS
ΔE = .087
P2
P1
ΔC = .36

Figure 7

The effectiveness probability of the September-November operational procedure can be computed by the formula*

$$\frac{\text{number of satisfied outgoing needs}}{\text{number of incoming needs}}$$

or for the operational procedures of September through November the effectiveness probability is $\frac{186}{230} = .81$.

The direct cost per need for September through November is

$$\frac{(230)(.29)+(230)(.03)+(230)(.93)+(207)(.40)+(219)(.52)+(13)(6.30)}{186}$$

$$= \frac{66.70 + 6.90 + 213.90 + 82.80 + 133.88 + 31.90}{186}$$

$$= \frac{566.08}{186} = \$3.05.$$

The delta index of cost-effectiveness for the operational procedures of September through November is $\frac{.81 - .72}{\$3.05-\$2.84} = \frac{.09}{.21} = .428$, relative to the operational procedural index for January through March. The delta index for operational procedures for May through June was .229.

After Task 5 is completed measures of cost-effectiveness of feasible alternative operational procedures are available and SCORE Analysis is finished. The following section "SCORE Analysis and P.P.B.S." describes how these measures may be used to facilitate programming, planning and budgeting.

SCORE ANALYSIS AND P.P.B.S.

Since funds should be allocated to increase effectiveness at the least cost per unit of effectiveness gained, the funds should be allocated to resolve the highest delta index of cost-effectiveness. Therefore, the library administrator in the sample case might adopt the policy of referring all needs not met by the original search to interlibrary loan and/or to an outside automated information retrieval service. If additional funds are available after this change, perhaps some recommunications and some second searches should also become part of the procedures.

In a case where no additional funds are allocated it may be necessary to exchange budget allocations between services or operations. For example, with a policy to reduce cost of cataloging by using Library of Congress proof slips as cataloging information and to add the funds saved to interlibrary loan operations, the index of cost-effectiveness may be increased

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* This formula can be used only when all needs are within the mission of the library and the objectives of the service.

SEA

EQ

ENTER

EVENT 1 -CASE IIIa

USER CONTACTS LIBRARIAN TO SATISFY INFORMATIONAL NEED.

230 NEEDS PER MO.
USER COMMUNICATES NEED FOR REFERENCE SERVICE

Average cost per need
$.29

EVENT 2

USER'S INFORMATIONAL NEED IS ADEQUATELY COMMUNICATED TO PROCESS THE NEED FURTHER.

PROBABILITY -- 1.00

230 NEEDS PER MO.
LIBRARIAN REVIEWS NEED

Average cost per need
$.03

EVENT 3

REFERENCE LIBRARIAN CONSIDERS CLIENT'S I AS WITHIN THE MISSIC THE LIBRARY AND BEG SEARCH.

PROBABILITY -- 1.00

REASON FOR NOT GIVING NEEDED SERVICE	SUB-PRO
a. Not within scope of the mission	
b. Priority of other tasks	

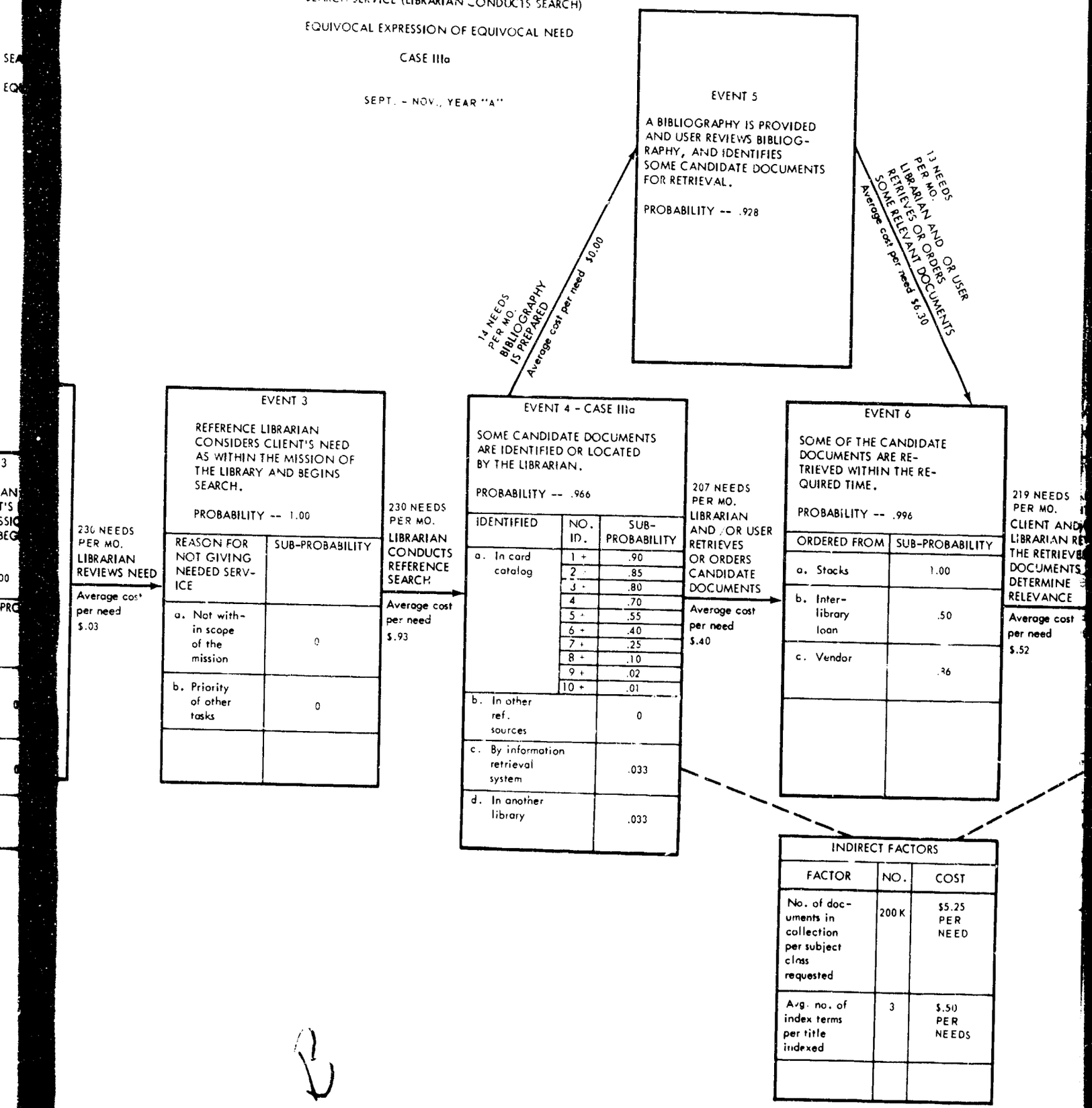
A

SEARCH SERVICE (LIBRARIAN CONDUCTS SEARCH)

EQUIVOCAL EXPRESSION OF EQUIVOCAL NEED

CASE IIIa

SEPT. - NOV., YEAR "A"



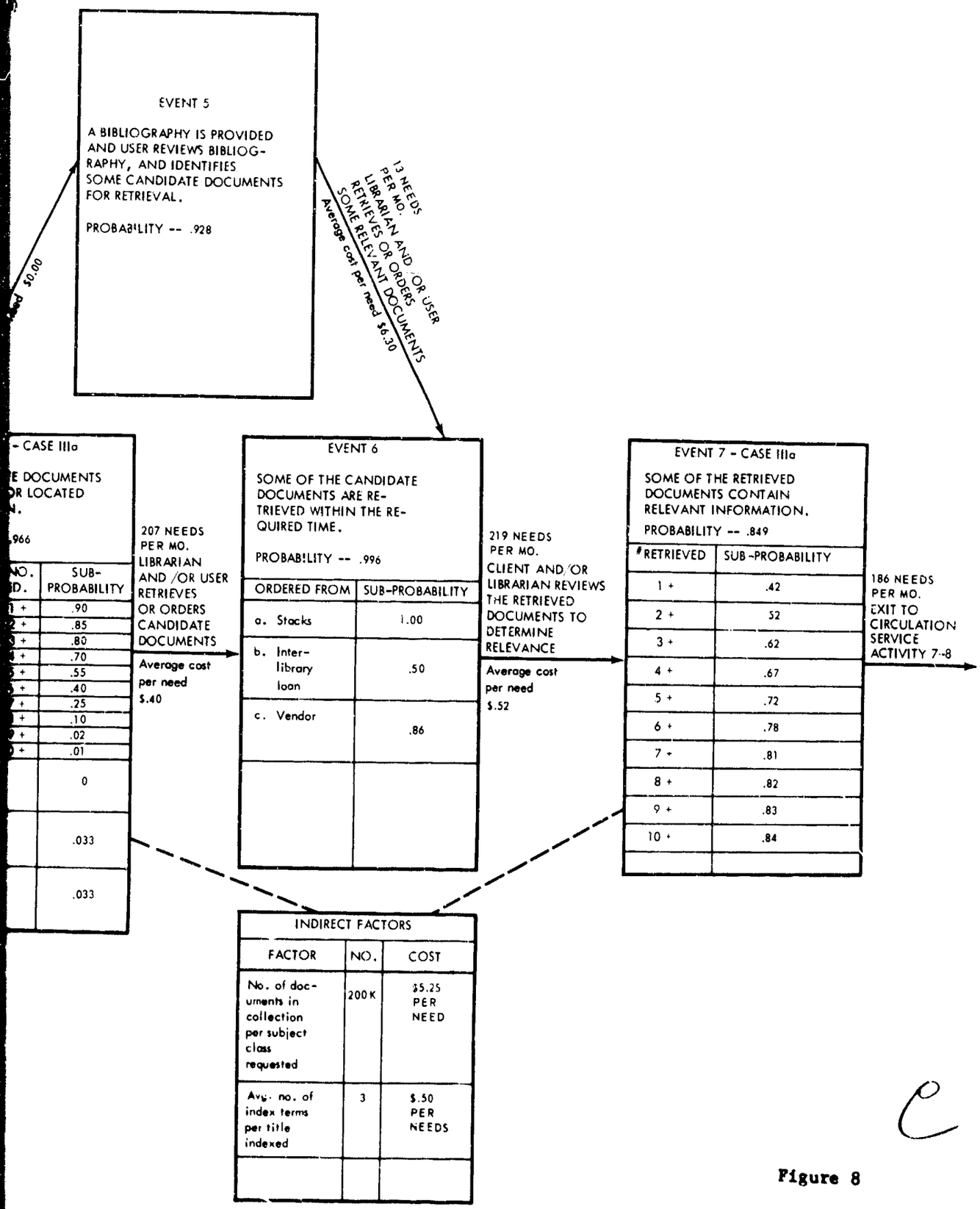

EVENT 5
A BIBLIOGRAPHY IS PROVIDED AND USER REVIEWS BIBLIOGRAPHY, AND IDENTIFIES SOME CANDIDATE DOCUMENTS FOR RETRIEVAL.
PROBABILITY -- .928
13 NEEDS PER MO. LIBRARIAN AND /OR USER RETRIEVES OR ORDERS SOME RELEVANT DOCUMENTS
Average cost per need $6.30
- CASE IIIa
E DOCUMENTS
R LOCATED
.966
NO. D.
SUB-PROBABILITY
.90
.85
.80
.70
.55
.40
.25
.10
.02
.01
0
.033
.033
207 NEEDS PER MO. LIBRARIAN AND /OR USER RETRIEVES OR ORDERS CANDIDATE DOCUMENTS
Average cost per need $.40
EVENT 6
SOME OF THE CANDIDATE DOCUMENTS ARE RETRIEVED WITHIN THE REQUIRED TIME.
PROBABILITY -- .996
ORDERED FROM
SUB-PROBABILITY
a. Stocks
1.00
b. Inter-library loan
.50
c. Vendor
.86
219 NEEDS PER MO. CLIENT AND /OR LIBRARIAN REVIEWS THE RETRIEVED DOCUMENTS TO DETERMINE RELEVANCE
Average cost per need $.52
EVENT 7 - CASE IIIa
SOME OF THE RETRIEVED DOCUMENTS CONTAIN RELEVANT INFORMATION.
PROBABILITY -- .849
RETRIEVED
SUB-PROBABILITY
1 +
.42
2 +
.52
3 +
.62
4 +
.67
5 +
.72
6 +
.78
7 +
.81
8 +
.82
9 +
.83
10 +
.84
186 NEEDS PER MO. EXIT TO CIRCULATION SERVICE ACTIVITY 7-8
INDIRECT FACTORS
FACTOR
NO.
COST
No. of documents in collection per subject class requested
200K
$5.25 PER NEED
Avg. no. of index terms per title indexed
3
$.50 PER NEEDS

Figure 8

within the same budget. The index of cost-effectiveness referred to here is the total effectiveness of the service divided by the average total cost per need = $\frac{E}{C}$.

In a case where funds are cut, allocations should be cut on operations and/or services to resolve the highest index of cost-effectiveness for total services.

In these cases we see the operative criteria of Programming-Planning and Budgeting Systems. P.P.B.S. uses these criteria to plan further into the future by extrapolating the existing trends and incorporating policies which can be predicted to resolve optimum cost-effectiveness. If the predictions are based on reliable data and valid criteria, performance can be controlled optimally by the budgeting process. For example, if measurements indicate that the index of cost-effectiveness is improved by using Library of Congress cataloging information to facilitate cataloging and by freeing some catalogers to assist reference librarians, a budget can be implemented to control the phasing in of the new operational procedures and policies and the allocation of manpower and other resources to cataloging and reference operations.

The budget should be structured to attain a goal. Thus the goal for a five-year program for search service may be to attain at the 5th year an effectiveness of .90 at a total cost of less than $8.00 (+ inflationary factor) per need. The number and kinds of needs entering the library per month should be projected for the five-year period. With the goal and the expected number of needs given, it then becomes possible to anticipate budget requirements for the service to meet the five-year goal. The P.P.B. System will not be described in detail in this report, since the primary purpose of this contract is to develop detailed methods of measuring performance. The P.P.B. System has been described briefly to indicate how the SCORE measures may be used in a P.P.B. System to improve and control performance.

SCORE Analysis can be used most appropriately to improve the percentage of needs met in given services. If some services yield more utility per need met than some other services, SCORE Analysis should not be used to improve the percentage of needs met in the services where utility per need is low at the expense of services where the utility per need is high. The utility concept is considered further in the following chapter on SCOUT Analysis.

V. SCOUT ANALYSIS--DETAILED DESCRIPTION*

The usage of SCOUT Analysis will be described in detail for a hypothetical A.T.L. Figure 9 represents the total and marginal utility schedule, as discussed in Chapter VIII of the Phase II report with some revisions. The following sections detail the tasks to be accomplished in SCOUT Analysis.

TASK 1

The first task to be accomplished in SCOUT Analysis is to list the services or products produced by the library (see 1, Figure 9, upper left hand corner). The services and products given in the hypothetical A.T.L. are Reference Search and Circulation, Circulation upon Request (no previous search), Circulation Predetermined, and Users Search and Circulation.

TASK 2

Task 2 lists all significant operations performed in the library (see 2, 2nd column from the left, Figure 9). The operations are listed and given symbols (see symbols A, B, C,...H) in the first column at the left.

TASK 3

Task 3 lists the significant materials used by the library in giving its services or products (see 3 in lower left corner). The only significant materials used at the hypothetical A.T.L. are books and documents. The symbol which represents these books and documents is I. The operations and books and documents are the only significant components of the services given at the hypothetical A.T.L. That is, the significant costs in operating the library are assignable to these components, except for management operations and other overhead components which will not be considered in SCOUT Analysis.

TASK 4

Task 4 lists the average existing man-hours assigned per week to each operation in the 3rd column from the left (see column marked 4 underlined quantities) and incremental deviations both above and below the existing man-hours (see input man-hours in column marked 4 not underlined). The total of the average existing man-hours per week should be the total man-hours on the job (that is, man-hours paid for) for the average week except for management operations.

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* Utility Analysis is discussed in principle in Chapter VIII of the Phase II report, p.87 through p.94. SCOUT Analysis is an outgrowth of these principles.

(1) SERVICE OR PRODUCT (6) Existing Utility of Each Service or Product in Meeting within-Mission Needs of the Users.			REFERENCE SEARCH & CIRCULATION	CIRCULATION (UPON REQUEST)	CIRCULATION PREDETERMINED	USERS SEARCH & CIRCULATION	Total & Marginal Utility Change of Operations			P_j	$\frac{MU_j^+}{P_j}$
			720	200	75	1400					
Operation Output Symbol	(2) Operation	Operation Input = Man-Hr. (4)	Utility Change (7)	Utility Change	Utility Change	Utility Change	Output-Std. Man-Hrs. of Work	TU_j Total Utility Change Per Week (8)	MU_j^+ Marginal Utility. Per Week Per Man-Hr. (11)	Price of Component (13)	(14)
A	Cataloging Actions	70 80 90	-100 + 55			-200 +150	70 80 90	-300 +205	-30.0 +20.5	5.00/man-hr.	-6.00 +4.10
B	Performance of Searches	30 40 50	-180 +155				30 40 50	-180 +155	-18.0 +15.5	5.00/man-hr.	-3.60 +3.10
C	Circulation Upon Request Actions	5 10 15		-100 + 2			5 10 15	-100 + 2	-20.0 + .4	3.00/man-hr.	-6.66 + .13
D	Circulation by Predetermined Listings Actions	10 20 30			-30 +10		10 20 30	-30 +10	-3.0 +1.0	3.00/man-hr.	-1.00 + .33
E	Preparation & Maintenance of Collection	10 20 30	-200 + 12	-50 + 4		-400 + 20	10 20 30	-650 + 36	-65.0 + 3.6	3.00/man-hr.	-21.7 + 1.2
F	Accessions Bulletin, Preparation & Distribution	5 10 15		-100 + 50			5 10 15	-100 + 50	-20.0 +10.0	3.00/man-hr.	-6.66 +3.33
G	Users' Education Actions	5 10 15	-10 +10	-5 +5	-2 +2	-200 +150	5 10 15	-217 +167	-43.6 +33.4	5.00/man-hr.	-8.73 +6.68
H	Acquisitions Actions (Selection, Ordering, & Receiving)	60 70 80	-70 +50	-50 +50	-10 +10	-50 +40	60 70 80	-180 +150	-18.0 +15.0	5.00/man-hr.	-3.6 +3.0
Material Symbol	Material (3)	Quantity (5)						Total Utility Change Per Week (10)	Marginal Utility Per Week Per 1000 (12)		
I	Books & Documents (Titles Only)	40 K 50 K 60 K	-22 + 8 (9)	-10 + 4	-10 + 5	-50 +20		-92 +37	-9.2 +3.7	\$5/week \$20/week	-1.8 + .19

Figure 9

TASK 5

Task 5 lists the quantity of materials and equipment which represent a significant investment, such as the books and documents collection, computer equipment and photographic equipment. For the purposes of this description we shall consider the hypothetical library as having only one significant investment in materials, that is, the books and documents collection. The collection size is then recorded in the quantity column (see column marked 3 lower left, Figure 9).

TASK 6

The sixth task assigns weights to each significant existing service or product given by the library. These weights represent the existing relative utility of each service or product in meeting the within-mission needs of the users. In order to derive equitable weights for the services and products the librarian must scout the services and products given to determine (1) the kinds and degrees of each service and product given, and (2) the effect of the information derived from the respective service or product in meeting a specific within-mission need or in leading the user to a potential approach for meeting his within-mission goals. It then becomes possible to weight the value or utility of each service and product. A number of different mechanisms can be used to facilitate the weighting exercise. The mechanisms used by the librarian to make determinations should depend upon his talents and experience. Each library SCOUT Analyst should develop a method which he can use best to derive measures which are consistent with effective planning, programming and budgeting for services. The following section, a method for generating services utility measures, describes the use of a few mechanisms which can facilitate weighting.

Method for Generating Services Utility Measures

After each service has been scouted estimates of the following parameters should be recorded:

1. The average number of needs met each week in each service.

2. Rank order of the value of the typical need met in each service. For example, in a library which has only three services, (a) users search and circulation, (b) circulation (upon request)* and (c) reference search and circulation, the judgment after scouting the services may be that the typical need met in users search and circulation is more valuable to the organization than the typical need for having publications circulated which were identified in accessions bulletins, but less valuable than the typical need met in reference search and circulation. The rank order of the value of each service's typical need are:

* Circulation (upon request) is circulation of titles requested by title and/or call number when the user has not conducted a catalog search.

reference search service #1, users search service #2, and circulation service (no catalog search) #3.

3. Ratings of the value of the typical (average) need met in each service. For example, assign an arbitrary value for the middle ranking service, e.g., users search = 10, then assign value ratings* relative to 10 for the typical need met for each of the other services while observing the rank order, such as circulation (no catalog search) = 4 and reference search and circulation = 12.

With these data available we are able to derive base utility measures for each service. For example, if there is an average of 50 needs for some (1 or more) items (books and documents) to be circulated per week where there has been no previous catalog search and the value of circulating these items is rated as 4 utils for the typical (average) need, the base utility measure for this circulation service is 4 X 50 = 200 utils. If there is an average of 140 users search needs met per week and the typical need met has a rating of 10 utils, the base utility for users search and circulation service is 1400 utils. If there is an average of 60 reference search needs met per week and the rating is 12 utils for the typical need met, the base utility for reference search and circulation service is 720 utils.

This mechanism can be used to derive base utility measures which can be recorded as the measure of utility, as in Figure 9 in the 2nd row from the top (see row marked 6). Since SCOUT Analysis is intended for quantifying subjective values, it is not necessary that the base utility measures be derived by this method. Furthermore, if this method is used for a base utility measure, it is not necessary to retain the base as the measure of utility. The base number can be adjusted according to values not considered in the development of the base utility. The base utility can be adjusted at any time during SCOUT Analysis to reflect the effect of new considerations. The utility measures should never be considered fixed or static, they simply reflect accumulated values based on empirical criteria in the mind of the SCOUT Analyst. The SCOUT Analyst whether he is the chief librarian or another official, must be accepted as an authority before the measures can be given credibility. The credibility of value judgments can be measured by the consistency of judgments between two or more qualified analysts. Credibility can also be judged according to the consistency of value judgments with policies, planning, programming and budgeting. Further credibility checks could include investigating the validity of the methods used for generating the values and also by investigating the reliability of the data which were used to derive the values.

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* Value ratings of "typical needs" should not be based purely upon the relevance of the information. A feasible mechanism for rating the value of information may be based upon the usefulness of the information in improving or reducing the solution probability of an approach to a problem. The solution probability of an approach to a problem is discussed by T.J. Allen in "Organizational Aspects of Information Flow in Technology," from the Proceedings of the 1968 Aslib Annual Conference. The anticipated benefits from reaching a solution should also be considered in the value judgments of information which is relevant.

TASK 7

Task 7 assigns expected changes in utility according to changes in man-hours for each operation. For example: if cataloging were assigned 70 man-hours per week instead of the existing 80 man-hours, we would expect that long-run utility of reference search and circulation would be reduced. The amount of reduction of utility of this service can be judged by a qualified SCOUT Analyst according to empirical criteria as in the judgment of utility of existing services. The following section describes some mechanisms which may be used to facilitate estimation of utility changes due to changes in operation outputs.

Method for Estimating Changes in Service Utility Due to Changes in Operation Outputs

The existing utility of reference search and circulation service was estimated to be 720 utils (see Figure 9). This figure was derived from an estimate of 60 needs met per week, where the typical (average) need was estimated to have a value of 12 utils in relation to the value of other service needs met. The reduction of 10 man-hours/week in cataloging (from 80 man-hours/week to 70 man-hours/week) would be expected to have some effect on the number of needs met and/or the amount of relevant information given in reference search and circulation service. At this point we can construct a utility curve. The existing utility of the service and the existing output of the operation is plotted as in Figure 10 (see plot "P_1"). An estimate is then made for the amount of time required for cataloging by author and title only. If this estimate is 30 man-hours per week, an estimate is made of the effect on the number of needs met due to elimination of subject indexing. An investigation of a sample of the needs met may suggest that only 10 of the 60 needs would have been met without subject indexing, and of these 10 needs the amount of relevant information given would have been less, and the value of the information given would have been 2 utils less relative to the 12 utils of the typical need met. Therefore, the total utility of the service, with only 30 standard man-hours of cataloging output per week, would be 10 x 10 or 100. This utility change and output of author and title indexing is plotted in Figure 10 (see plot "P_2").

Next a study can be made of a sample of the needs met to determine the recall ratio.* If the recall ratio was .80, an estimate is made as to the number of man-hours required for subject cataloging which would give a recall ratio of perhaps .90; this estimate is 120 man-hours per week which, we may judge, would double the number of subject index terms. An estimate is then made that the value of the typical need met would increase from 12 to 14 utils. The utility of the 60 needs then would be 14 x 60 or 840. Furthermore, assume that in the experience of the

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* Recall ratio = $\frac{\text{No. of relevant documents recalled}}{\text{No. of relevant documents in collection}}$

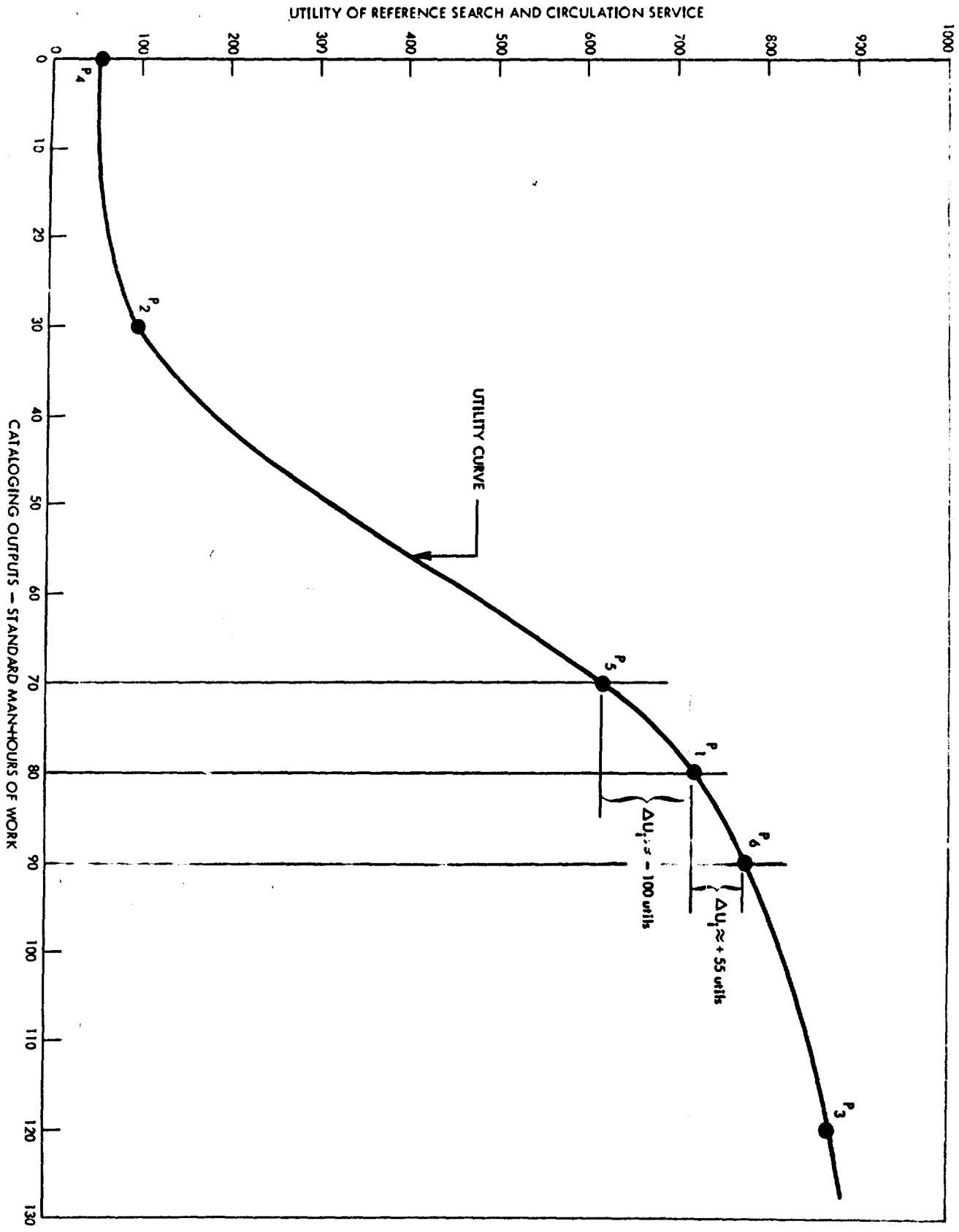
UTILITY OF REFERENCE SEARCH AND CIRCULATION SERVICE
0
100
200
300
400
500
600
700
800
900
1000
CATALOGING OUTPUTS – STANDARD MANHOURS OF WORK
0
10
20
30
40
50
60
70
80
90
100
110
120
130
UTILITY CURVE
P4
P2
P5
P1
P6
P3
ΔU ≈ – 100 units
ΔU ≈ + 55 units

Figure 10

reference service an average of 10 needs are not met during each week. The increase in indexing operations would be expected to reduce the number of needs not met, and therefore increase the average number of needs met. For example, the increase in recall ratio due to doubling subject indexing is expected to satisfy 2 of the 10 needs which would otherwise not have been met. This increases the number of needs met per week to 62. The total base utility of reference search and circulation service would then become 62 x 14 or 868 utils. This point is plotted in Figure 10 as "P_3."

The next step is to consider the effect on the utility of reference search service if no catalog is available. If this were the case, a small percentage of the needs may still be met. A study of the needs met may indicate that an average of 5 needs are met each week by the reference librarian by recalling information from memory which is relevant and adequate to satisfy the need. Assume that the utility of this class of needs is estimated as 11 utils relative to the 12 utils typical of the existing reference search needs met. The estimate of the base utility of reference search and circulation service with no catalog available based upon 11 utils per need for 5 needs met is 11 x 5 or 55 utils. This point is plotted as "P_4" in Figure 10. The points can now be joined by a smooth curve which represents the utility curve* of reference search and circulation service with increasing cataloging outputs (see curve in Figure 10).

With the utility curve given, it is now possible to determine the change in utility of the service with a given change in operation outputs. The utility change from 80 to 70 man-hours per week can be derived from the difference in utility between "P_5" and "P_1" (see Figure 10) or approximately 100 utils. The man-hour change is then recorded in the total and marginal utility change chart (see Figure 9, column 4). The utility change from 80 to 90 man-hours per week is approximately +55 utils. The utility change +55 utils is then recorded in the schedule (see Figure 9, column 7).

This procedure can be continued to fill the matrix in the utility schedule at all coordinates where operations, materials and other components affect service utility.

TASK 8

Task 8 sums the utility changes for each operation and records the sum in the total utility change column of the utility schedule (see column marked 8, upper right, Figure 9).

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* This utility curve is meaningful only when all other components which affect utility of the service are held constant.

TASK 9

This task assigns expected changes in utility according to changes in quantities of materials such as books, documents and periodicals in the collection. For example, a change from a collection size of 50K items to 55K items would be expected to give additional utility to some of the services. Value judgments of the utility of a collection can be based on several criteria such as the user subject area coverage by the collection, the amount of use of a collection, the percentage of needs which are provided with sufficient relevant information from the collection to satisfy the need. The criteria used should be the choice of the SCOUT Analyst. The following section describes some mechanisms which may be used to facilitate Task 9.

Method for Estimating Changes in Service Utility Due to Changes in Collection Size

In analyzing the effectiveness of a collection we must think in terms of long-run effectiveness. If the existing collection size is 50,000 and the percentage of needs met per week in reference search and circulation service measures 83% ± 5%, e.g., 90% of the time, we have a reliable measure of the effectiveness of the collection in terms of the probable percentage of needs met. This condition (50,000 collection size and 83% coverage) can be plotted on a utility chart (see "P_1," Figure 11). After plotting "P_1" we may identify 10%, that is, 5000 of the titles in the collection. This can be accomplished by selecting all titles with an accession number ending in digit 1, if the numbers are chronologically assigned and consecutive. From a study of the needs met we can determine the number of needs which would not have been met if the identified 5,000 titles were not in the collection. Assume a study shows that 1% ± .5% of the needs would not have been met 90% of the time. Then we can deduce that with a collection size of 45,000 titles only 82% of the needs would have been met. This state (45,000 titles and 82%) is then plotted (see "P_2," Figure 11). After plotting "P_2" we shall select all titles with an accession number ending in digit 2 and plot the predicted percentage of needs met with a collection size of 40,000 titles. The study thus shows that 80% ± 5% of the needs would have been met 90% of the time (see "P_3", Figure 11). The points are then joined by a smooth curve which represents the effectiveness of the collection size in terms of needs coverage. The smooth curve is extrapolated both forward and backward* to reflect an estimated coverage effectiveness curve for a collection size of a range sufficient for adequate and confident planning, programming and budgeting. The next step in Task 9 is to determine the change in utility of the service due to change in collection size. At the hypothetical library a reduction of collection size from 50K to 40K (plotted in Figure 9,

* With sufficient time the curve for collection sizes less than the existing size can be determined without backward extrapolation.

see column marked 5) will reduce effectiveness of reference search and circulation service by 3% (see Figure 11). This represents a change in utility of the service of (-.03) x (720) = -22 utils. Also, a change from 50K to 60K (plotted in Figure 9, column 5) is predicted to increase the utility by 1%. This represents a change in utility of (+.01)x(720) = 8 utils. These utility measures are then recorded in the utility schedule (see column marked 9, Figure 9). This process can be continued until the utility schedule is completed for the change in utility of all services according to given changes in collection size.

TASK 10

This task sums the utility of books and documents for the quantities listed (see column marked 10, lower right, Figure 9).

TASK 11

The eleventh task determines the marginal utility of the components, which is computed by the formula:

$$\frac{\text{total utility change}}{\text{quantity change}}$$

For operations the quantity will be in standard man-hours of work. For books and documents the quantity will be the number of titles. The marginal utility of cataloging between 70 and 80 man-hours output will be $\frac{-300}{10} = -30$. The marginal utility is then recorded in the marginal utility schedule (See Figure 9, columns 11 and 12). Task 11 completes the schedule of base utility and marginal utility measures. The measures are, however, subject to change according to criteria not previously considered in the analysis. We shall, therefore, consider other criteria in Task 14 (see p. 50) and describe how the utility measures may be altered and used for planning, programming and budgeting.

TASK 12

This task determines if the collection size should be changed. Assume that at the present the library is acquiring 100 books and documents per week for 50 weeks a year. This is a total of 5,000 items a year. At this rate in 10 years the collection size would increase by 50,000 items, assuming there is no weeding. However, most A.T.L.'s have weeding policies. Therefore, let us assume that the policy at the hypothetical library is to weed 10% of the collection each year in order to maintain a collection from year to year which would be of equal value to the users for given collection sizes. Therefore, to maintain a 50,000 collection size it will be necessary to acquire 5,000 items per year or approximately 100 items per week to keep the collection from depreciating in value. This expenditure must be taken from the top of the budget to make the utility analysis valid. The validity of the base utility values for operations depends upon holding the value of the base collection size (existing collection size) constant. For the

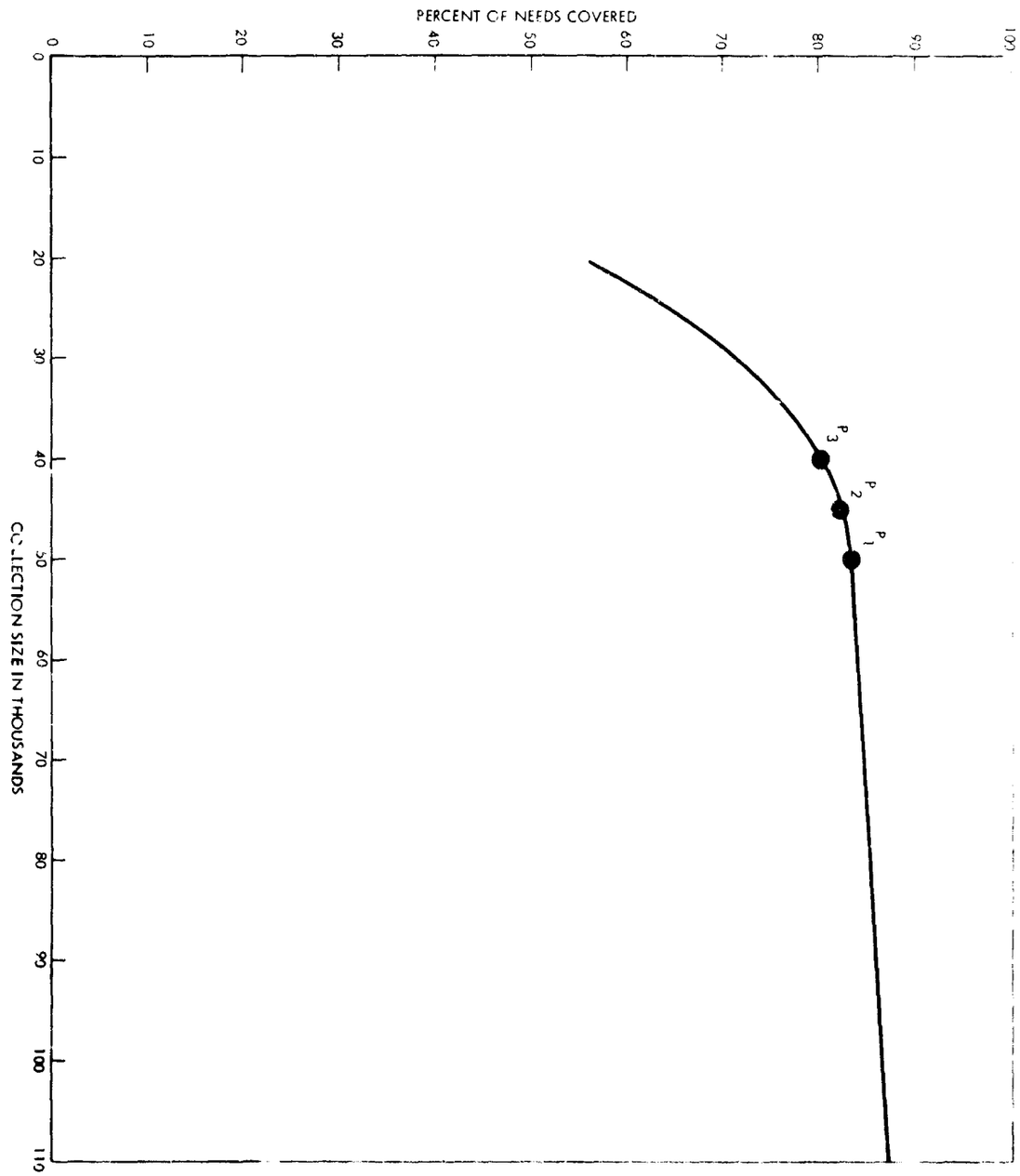
PERCENT OF NEEDS COVERED
0
10
20
30
40
50
60
70
80
90
100
COLLECTION SIZE IN THOUSANDS
0
10
20
30
40
50
60
70
80
90
100
110
P3
P2
P1

Figure 11

hypothetical library the base collection size is 50,000 items. We now continue the analysis to determine if the collection size should be changed. The analysis indicates that we can expect approximately 3.7 utils per week increase for each 1,000 items added to the collection, which is in addition to base replacement items. A cost accounting of the items purchased in the past will determine the cost per 1,000 items. This includes all costs of getting the items in-house and the costs of ordering, processing and cataloging, if additional man-hours are required over the existing man-hours required for base replacement. For the hypothetical A.T.L. let us assume that the cost is $10,000 per 1,000 items and that the lifetime of the average title is 10 years. The amortized cost for 1,000 titles for a year would be $1,000. The amortized cost for a week would be $20.00. We can now determine if it is practical to increase the collection size.

Collection size should be increased, if MU_j/P_j of collection size is the largest MU_j/P_j where MU_j is the component's marginal utility and P_j is the component's cost per unit. MU_j^+/P_j for collection size is MU_I^+/P_I or 3.7/$20 = .19 and is smaller than MU_A^+/P_A; therefore collection size should not be increased without first increasing cataloging and other components until MU_j^+/P_j of all components is .19 or less. We should also not decrease collection size by weeding in excess of 10% per year or by performing less than 100% base replacement, since the decreasing marginal utility MU_I^-/P_I is not the smallest MU_j^-/P_j. $MU_I^-/P_I = -9.2/5 = -1.8$. Circulation by predetermined listings should be decreased first, since its decreasing marginal utility $MU_E^-/P_E = -3.0/\$3.00 = -1.0$ and is the smallest MU_E^-/P_E for decreasing inputs.

The analysis of the marginal utility and unit cost of items in the collection has indicated that the collection base size should not be the first component changed. With the collection size, value and funding held constant we can now proceed to analyze the equilibrium of operations, that is, we can determine if the funds are properly distributed between operations to maximize the utility of the services within budget constraints.

TASK 13

This task determines the state of equilibrium of the operations performed. The equilibrium condition for maximum utility exists when total budget for operations (I); amount of each operational output (A,B,C,...N);

price of each operational unit (Pa, Pb, Pc,...Pn) and marginal utility of each operational unit (MUa, MUb, MUc...MUn) satisfy the following equations

$$(1)\ I=(A)(Pa)+(B)(Pb)+(C)(Pc)+\ldots+(N)(Pn);$$

$$(2)\ \frac{MUa}{Pa}=\frac{MUb}{Pb}=\frac{MUc}{Pc}=\ldots=\frac{MUn}{Pn}.$$

The following value table (Table 1) lists the values for these equations for the hypothetical A.T.L. Compare these data to data in columns marked 4, 11 and 13 of Figure 9.

Table 1 - Value Table

I = $1240 per week*		Increasing MU_j	Decreasing MU_j
A = 80 std. man-hrs of work	Pa = $5.00/man-hr.	MU_a^+ = +20.5	MU_a^- = -30.0
B = 40 std. man-hrs of work	Pb = 5.00/man-hr.	MU_b^+ = +15.5	MU_b^- = -18.0
C = 10 std. man-hrs of work	Pc = 3.00/man-hr.	MU_c^+ = + .4	MU_c^- = -20.0
D = 20 std. man-hrs of work	Pd = 3.00/man-hr.	MU_d^+ = + 1.0	MU_d^- = - 3.0
E = 20 std. man-hrs of work	Pe = 3.00/man-hr.	MU_e^+ = + 3.6	MU_e^- = -65.0
F = 10 std. man-hrs of work	Pf = 3.00/man-hr.	MU_f^+ = +10.0	MU_f^- = -20.0
G = 10 std. man-hrs of work	Pg = 5.00/man-hr.	MU_g^+ = +33.4	MU_g^- = -43.6
H = 70 std. man-hrs of work	Ph = 5.00/man-hr.	MU_h^+ = +15.0	MU_h^- = -18.0

* $1240 per week is the budget for operations listed. This does not include budgets for overhead, management and for purchases of materials (including books & documents) and equipment.

Using the values in Table 1, equation (1) becomes

$$\begin{aligned}(1)\quad \$1240 &= (80)(5.00)+(40)(5.00)+(10)(3.00)\\ &+ (20)(3.00)+(20)(3.00)+(10)(3.00)\\ &+ (10)(5.00)+(70)(5.00)\\ &= \$400 + \$200+\$30+\$60+\$60+\$30+\$50+\$350\\ &= \$1180.\end{aligned}$$

From equation (1) it can be seen that the operational costs do closely approximate the budgeted figure. Only $60 per week is lost in expenses not accounted for.

To determine if the operations are in equilibrium we must interpolate MUj, for the existing point on the total utility curve for each operation $MUj = (MU_j^+ - MU_j^-)/2$. Therefore, MUa = (20.5* + 30.0*)/2 = 50.5/2 = 25.25, MUb = 16.75, MUc = 10.2, MUd = 2.00, MUe = 34.30, MUf = 15.00, MUg = 38.50, MUh = 16.50. The next step is to substitute the values of MUj's and P_j's in equation (2).

$$(2): \quad \frac{25.25}{5.00} = \frac{16.75}{5.00} = \frac{10.2}{3.00} = \frac{2.00}{3.00} = \frac{34.30}{3.00} = \frac{15.00}{3.00} = \frac{38.50}{5.00} = \frac{16.50}{5.00} ;$$

$$(2): \quad 5.05 = 3.35 = 3.40 = .66 = 11.43 = 5.00 = 7.70 = 3.30.$$

Equation (2) is not in equilibrium. Therefore, the operations are out of equilibrium and funds should be budgeted to improve this. Funds should be added to operations where MU_j^+/P_j is largest and funds should be removed from operations where MU_j^-/P_j is smallest.

TASK 14

The fourteenth task determines which operations should be reduced first and which should be increased first if they are not in equilibrium. The MU_j^+/P_j values (see positive values in column marked 14, Figure 9) from highest to lowest are: user education actions +6.68, cataloging action +4.10, accessions bulletin preparation and distribution +3.33, performance of searches +3.10, acquisitions actions +3.0, preparation and maintenance of collection +1.2, circulation by predetermined listings actions +.33, circulation upon request actions +.13. This is the order in which funds should be added, first to user education, second to cataloging actions, and so on. If no additional funds are allocated, it will be necessary to reduce funds from some operations where it is possible to approach equilibrium. Funds should be reduced where MU_j^-/P_j is smallest (see negative values in column marked 14, figure 9). The first reduction should be in circulation by predetermined listings where $MU_D^-/P_D = -1.00$, the 2nd reduction should be in performance of searches where $MU_B^-/P_B = -2.60$, and so on.

* See column marked 11, in Figure 9

Before predetermined circulation is reduced to increase user education actions, we must consider the short-run and long-run effects. Many factors should be considered before such a change is made, such as (1) Can predetermined circulation be made more efficient to reduce the cost per item circulated sufficiently to increase MU_D^-/P_D above the level of the second lowest MU_j^-/P_j operation? (2) Would the long-run advantages of increasing user education offset the short-run disadvantage of poor public relations effects of reducing predetermined circulation services which the users have become accustomed to receiving? (3) Would a sufficient number of users accept reduced predetermined circulation and increased user education to the extent that MU_D^-/P_D can be increased above the level of the second lowest MU_j^-/P_j? (4) Would officials in the organization accept the proposals for increased user education? The number of relevant factors to be considered before making such a change would in most cases exceed 4, but many of them would not be high priority considerations.

The next step is to determine if any factors are effective barriers to reduction of predetermined circulation or to increasing user education. For example, if none of the proposals for user education programs are accepted regardless of the effort made to develop the programs, factor 4 may be an effective barrier to utility maximization. Again, officials may have convictions that the value of user education is overestimated. If this is the case, the SCOUT Analyst should revise the estimates of utility according to valid utility considerations introduced.

After thorough consideration of the factors relevant to making the change and if factor MU_D^-/P_D remains the lowest MU_j^-/P_j after changes in utility estimates and/or efficiency and if there are no effective barriers outstanding, a reduction should be planned, proposed to top management and implemented if approved. If MU_D^-/P_D continues to be the lowest MU_j^-/P_j and if there are effective barriers such as (1) nonutilitarian considerations or (2) factors which would prohibit released labor from assuming more utility-maximizing tasks, the reduction should not necessarily be made.

Increases in operational activity should be implemented for operations where MU_j^+/P_j remains the highest after utility and/or efficiency adjustments are made, unless there are effective barriers

Where barriers exist, reductions or increases should be made on operations to maximize utility until the barriers become effective; that is, until nonutilitarian considerations, considerations of costs not paid by

the library (as user time) and other extenuating circumstances prohibit further reduction of low MU_j^-/P_j operations or further increase of high MU_j^+/P_j operations.

After completion of Task 14 the utility schedule should be complete. That is, all appropriate adjustments of utility should have been made, and meaningful, useful effectiveness measures are available as a basis for planning, programming and budgeting.

VI. CORE ANALYSIS--DETAILED DESCRIPTION*

The usage of CORE Analysis will be described for cataloging; however, it will be useful in all areas where operational costs and quantity correlate highly among A.T.L.'s and where effectiveness (quality of outputs) of the operations at each library can be placed in definable quality classes.

TASK 1

The first task is to plot the cost and output of the operation at each library participating in the analysis. (See Figure 12).

TASK 2

The second task computes the coefficient of correlation (r).

where: $r^{**} = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2 \Sigma(y-\bar{y})^2}}$

The values and their meaning are found in Table 2 for a hypothetical sample case. The cost vs. the number of titles cataloged in this example has a correlation coefficient of approximately .57. The highest possible correlation is ± 1.00. The correlation coefficient indicates that a unit cost standard for all cataloging would be too loose. We should, therefore, attempt to identify classes of cataloging in terms of quality.

TASK 3

If the correlation is weak, the next task is to develop a quality continuum for cataloging (see Figure 13) and identify the position of each library's cataloging quality by sampling.

In this hypothetical example, all libraries which do only descriptive cataloging will be placed in class 1; let us assume these libraries are Nos. 8, 23, 19, 44, 13, 38, 48, 28, 39 and 47.

TASK 4

This task computes the coefficient of correlation (r) for the 10 libraries doing only descriptive cataloging. The values in Table 2 are substituted in the equation and the value of r is determined as follows:

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* CORE Analysis is discussed in principle in Chapter VI of the Phase II report, p. 49 through 58 under data correlation considerations.

** The correlation coefficient r may be used as an index measuring the closeness of fit of the points to a least squares regression line of best fit (see Task 5).

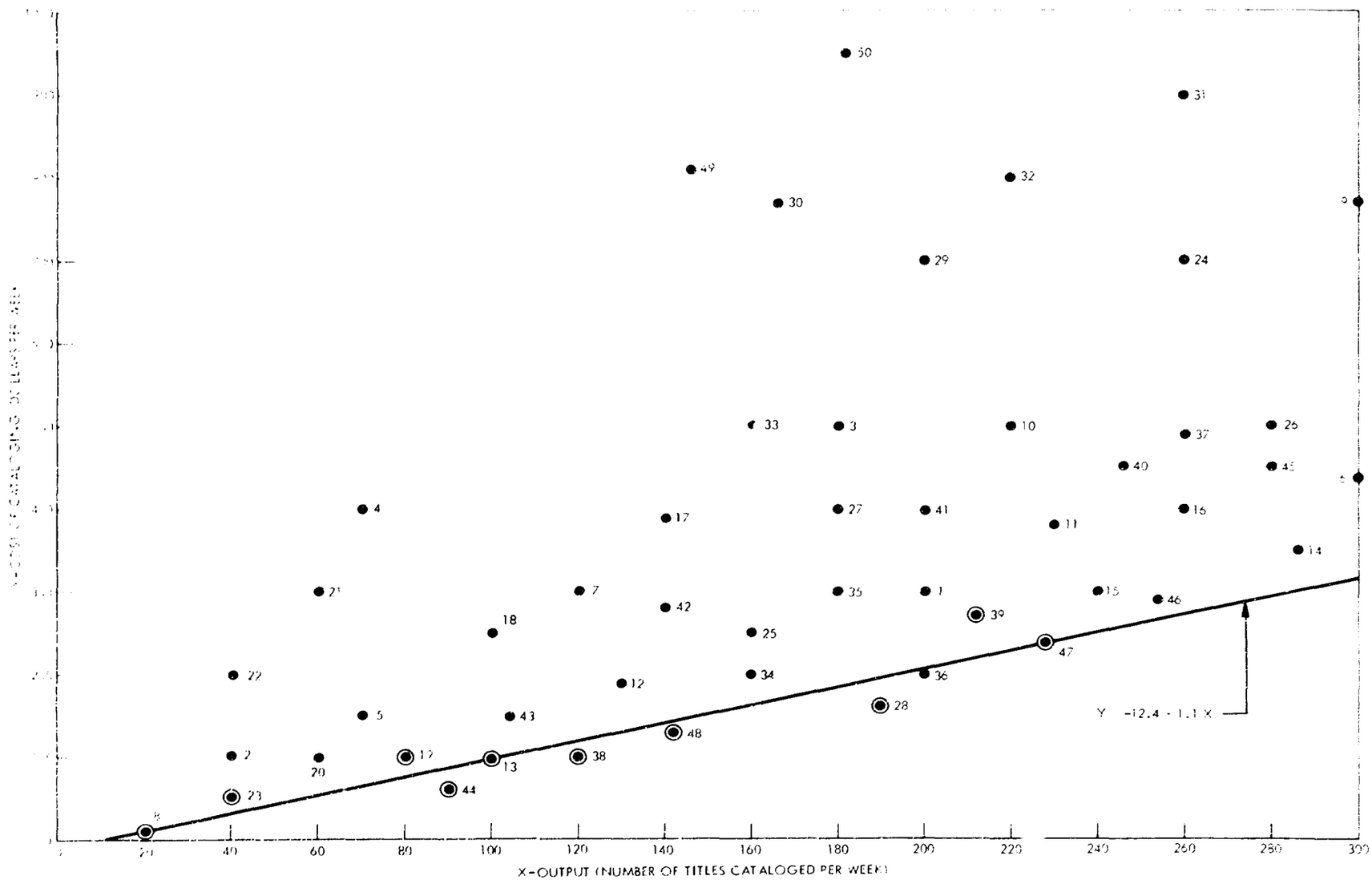
X-OUTPUT (NUMBER OF TITLES CATALOGED PER WEEK)
Y = -12.4 + 1.1 X
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

Figure 12

TABLE 2

Point	X	Y	$(X - \bar{X})$	$(X - \bar{X})^2$	$(Y - \bar{Y})$	$(Y - \bar{Y})^2$	$(X - \bar{X})(Y - \bar{Y})$
1	200	300	29.88	892.8	- 60.6	3672.4	- 1810.7
2	40	100	-130.12	16931.2	-260.60	67912.4	33909.3
3	180	500	+ 9.88	97.6	139.40	19432.4	+ 1377.3
4	70	400	-100.12	10024.0	39.40	1552.4	- 3944.7
5	70	150	-100.12	10024.0	-210.60	44352.4	21085.3
6	300	440	129.88	16868.8	79.40	6304.4	10312.5
7	120	300	- 50.12	2512.0	- 60.60	3672.4	3037.3
8	20	10	-150.12	22536.0	-350.60	122920.4	52632.1
9	300	770	129.88	16868.8	409.40	167608.4	53172.8
10	220	500	49.88	2488.0	139.40	19432.4	6953.3
11	230	380	59.88	3585.6	19.40	376.4	1161.7
12	130	190	- 40.12	1609.6	-170.60	29104.4	6844.5
13	100	100	- 70.12	4916.8	-260.60	67912.4	18273.3
14	286	350	115.88	13428.2	- 10.60	112.4	- 1228.3
15	240	300	69.88	4883.2	- 60.60	3672.4	- 4234.7
16	260	400	89.88	8078.4	39.40	1552.4	3541.3
17	140	390	- 30.12	907.2	29.40	864.4	- 885.5
18	100	250	- 70.12	4916.8	-110.60	12232.4	7755.3
19	80	100	- 90.12	8121.6	-260.60	67912.4	23485.3
20	60	100	-110.12	12126.4	-260.60	67912.4	28697.3
21	60	300	-110.12	12126.4	- 60.60	3672.4	6673.3
22	40	200	-130.12	16931.2	-160.60	25792.4	20897.3
23	40	50	-130.12	16931.2	-310.60	96479.4	40415.3
24	260	700	89.88	8078.4	339.40	115192.4	30505.3
25	160	250	- 10.12	102.4	-110.60	12232.4	1119.3
26	280	500	109.88	12073.6	139.40	19432.4	15317.3
27	180	400	9.88	97.6	39.40	1552.4	389.3
28	190	160	19.88	395.2	-200.60	40240.4	- 3987.9
29	200	700	29.88	892.8	339.40	115192.4	10141.3
30	166	770	- 4.12	17.0	409.40	167608.4	- 1686.7
31	260	900	89.88	8078.4	539.40	290952.4	48481.3
32	220	800	49.88	2488.0	439.40	193072.4	21917.3
33	160	500	- 10.12	102.4	139.40	19432.4	- 1410.7
34	160	200	- 10.12	102.4	-160.60	25792.4	1625.3
35	180	300	9.88	97.6	- 60.60	3672.4	- 598.7
36	200	200	29.88	892.8	-160.60	25792.4	- 4798.7
37	260	490	89.88	8078.4	129.40	16744.4	11630.5
38	120	100	- 50.12	2512.0	-260.60	67912.4	13061.3
39	212	270	41.88	1755.9	- 90.60	8028.4	- 3794.3
40	246	450	75.88	5757.8	89.40	7992.4	6783.7
41	200	400	29.88	892.8	39.40	1552.4	1177.3
42	140	280	- 30.12	907.2	- 80.60	6496.4	2427.7
43	104	150	- 66.12	4371.9	-210.60	44352.4	13924.9
44	90	60	- 80.12	6419.2	-300.60	90360.4	24084.1
45	280	450	109.88	12073.6	89.40	7992.4	9823.3
46	254	290	83.88	7035.9	- 70.60	4984.4	- 5921.9
47	228	240	57.88	3350.1	-120.60	14544.4	- 6980.3
48	142	130	- 28.12	790.7	-230.60	53176.4	6484.5
49	146	810	- 24.12	581.6	449.40	201960.4	-10839.5
50	182	950	11.88	141.1	589.40	347392.4	7002.1

N=total no. of points = 50

ΣX = sum of column X = 8506

ΣY = sum of column Y=18030

$\Sigma (X - \bar{X})^2$ = sum of nos. in column $(X - \bar{X})^2$ = 295890.8

$\Sigma (Y - \bar{Y})^2$ = sum of of nos. in column $(Y - \bar{Y})^2$ = 2738292.0

$\Sigma (X - \bar{X}) \cdot (Y - \bar{Y})$ = sum of the products nos. in columns $(X - \bar{X})$ and $(Y - \bar{Y})$ = 513997.7

$\bar{X}$ = average of nos. in column X = $\Sigma X/N$ = 8506/50 = 170.12

$\bar{Y}$ = average of nos. in column Y = $\Sigma Y/N$ = 18030/50 = 360.60

$$r = \frac{\Sigma (X - \bar{X})(Y - \bar{Y})}{\sqrt{\Sigma (X - \bar{X})^2 (Y - \bar{Y})^2}} = \frac{5.14 \times 10^5}{\sqrt{(2.96 \times 10^5)(27.4 \times 10^5)}}$$

$$= \frac{5.14 \times 10^5}{81.0 \times 10^{10}} = \frac{5.14 \times 10^5}{9.0 \times 10^5} = .57$$

QUALITY CONTINUUM

CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5
DESCRIPTIVE CATALOGING	1 TO 3 UNSPECIALIZED SUBJECT TERMS USING PRECEDENT SUCH AS L. C. PROOF SLIPS	2 TO 4 SUBJECT TERMS SEMISPECIALIZED IN USERS' FIELDS - USING PRECEDENT ADAPTATION	3 TO 5 SUBJECT TERMS SPECIALIZED IN USERS' FIELDS - ORIGINAL CATALOGING	5 OR MORE SUBJECT TERMS SPECIALIZED IN USERS' FIELDS - ORIGINAL CATALOGING

Figure 13

TABLE 3

VALUE TABLE - CLASS 1

POINT	X	Y	$(X-\bar{X})$	$(X-\bar{X})^2$	$(Y-\bar{Y})$	$(Y-\bar{Y})^2$	$(X-\bar{X})(Y-\bar{Y})$	X^2	XY
8	20	10	-102	10404	-112	12544	11424	400	200
23	40	50	- 82	6724	- 72	5184	5904	1600	2000
19	80	100	- 42	1764	- 22	484	924	6400	8000
44	90	60	- 32	1024	- 62	3844	1984	8100	5400
13	100	100	- 22	484	- 22	484	484	10000	10000
38	120	100	- 2	4	- 22	484	44	14400	12000
48	142	130	+ 20	400	+ 8	64	160	20164	18460
28	190	160	+ 68	4624	+ 38	1444	2584	36100	30400
39	212	270	+ 90	8100	+148	21904	13320	44944	57240
47	228	240	+106	11236	+118	13924	12508	51984	54720
	$\Sigma X = 1222$	$\Sigma Y = 1220$		$\Sigma(X-\bar{X})^2 =$		$\Sigma(Y-\bar{Y})^2 =$	$\Sigma(X-\bar{X})\cdot(Y-\bar{Y}) =$	$\Sigma X^2 =$	$\Sigma XY =$
	$\bar{X} \approx 122$	$\bar{Y} = 122$		44764		60360	49336	194092	198420

$$r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2\Sigma(y-\bar{y})^2}} = \frac{49.3 \times 10^3}{\sqrt{(44.8 \times 10^3)(60.4 \times 10^3)}}$$

$$= \frac{49.3 \times 10^3}{\sqrt{27.2 \times 10^8}} = \frac{49.3 \times 10^3}{(5.22 \times 10^4)(60.4 \times 10^3)} = .95$$

The cost vs. the number of titles cataloged descriptively for class 1 has a correlation coefficient of .95. Any correlation above .90 should be considered adequate for developing a tight standard for the class in the quality continuum. If the correlation coefficient is below .80 for a class, the class should be divided further on the quality continuum. This dividing process should continue until a correlation of .80 or better is reached or until no further distinction in quality can be made.

For quality classes which cannot be divided further or which have two or less members or which have a correlation coefficient lower than .80, it is recommended that GAME Analysis be used instead of CORE Analysis for developing standards.

TASK 5

This task computes the line of best fit for the points in a quality class by the method of least squares. The equation for the line of best fit can be obtained by solving the following simultaneous general equations (1) and (2) for a and b :

(1) $\Sigma y = an + b\Sigma x$ where: n = number of points in the class

(2) $\Sigma xy = a\Sigma x + b\Sigma x^2$

and by substituting the values of a and b in the following general equation (3) for the line of best fit :

(3) $y = a + bx$.

Using the values in Table 3, equations (1) and (2) become

(1) $1220 = a(10) + b\ (1222)$

(2) $198420 = a(1222) + b(194092)$

In solving the simultaneous equations, first one constant (a or b) is eliminated as follows:

multiply (1) by -1,222 and name the new equation (4)

$$(4) \quad -1{,}490{,}840 = (-12{,}220)a + (-1{,}493{,}284)b;$$

multiply (2) by +10 and name the new equation (5)

$$(5) \quad 1{,}984{,}200 = (12{,}220)a + (1{,}940{,}920)b;$$

add equation (4) and (5) and solve for b:

$$(4) \quad -1{,}490{,}840 = -12{,}220a - 1{,}493{,}284b$$

$$(5) \quad \underline{1{,}984{,}200 = 12{,}220a + 1{,}940{,}920b}$$

$$493360 = 447636b$$

$$b = \frac{493360}{447636} = 1.1;$$

substitute b in equation (1) and solve for a:

$$(1) \quad 1220 = 10a + 1344.2$$

$$10a = -124.2$$

$$a = -12.4;$$

substitute a and b in equation (3) and name it equation (6)

$$(6) \quad y = -12.4 + 1.1x$$

where y = weekly cost of descriptive cataloging, and

x = the number of titles descriptively cataloged per week.

TASK 6

Task 6 is to draw the line of best fit in the scatter diagram (see Figure 12). This is accomplished by connecting any two points which satisfy equation (6), such as the two points described below:

point (1) when: $x = 100$, $y = 110 - 12.4 = 97.6$;

point (2) when: $x = 300$, $y = 330 - 12.4 = 317.6$.

The line y = -12.4 + 1.1x is the standard for descriptive cataloging where the cost (y) should be $1.10 times the number of titles cataloged descriptively (x) less $12.40.

CORE Analysis and Performance Control

Libraries which deviate most from the line of best fit on the costly side should be investigated to determine if the higher costs are justifiable. Library #39 should be compared with a library working closer to the standard which performs approximately the same volume of work, such as library #47. If the comparison shows that library #39 does not have more effective descriptive cataloging and if extenuating circumstances are not apparent, library #39 should be expected to improve methods and efficiency and to work to the standard.

Libraries which deviate most on the low cost side of the line of best fit should be investigated to determine if the quality of cataloging should be higher.

After an analysis of the deviates by comparison with the conformists, sufficient experience should have been gained to declare the standard and to formulate policies for performance control by standardization of costs and quality.

The development of CORE standards is independent of methods used in processing. CORE standards should be used to control input costs and output quality. The methods used in processing and the individual operator's efficiency are not studied by the CORE Analyst. CORE standards can be developed without imposition of standard times or standard methods upon the operations. As long as costs and quality do not deviate beyond the desired normal ranges, the operations managers are free to select the methods to be used for operations. Where CORE Analysis fails to provide a tight standard, it will be necessary to define the methods to be used and develop standards for elements of work. Chapter VII discusses GAME Analysis -- a technique for developing standard methods and standard times or costs for accomplishing a desired output.

CORE standards can be used to measure the relative efficiency of operations between A.T.L.'s for given levels of effectiveness. The index of efficiency (E) is computed by:

$$E = \frac{a + bx}{C},$$

where C is the actual cost for production of x. If E is below 1.0, the operational efficiency is below par. If E is above 1.0, the operational efficiency is above par.

VII. GAME ANALYSIS*--DETAILED DESCRIPTION

TASK 1

The first task in GAME Analysis is to construct a flow chart of the activities in a process. For example, Figure 14 is a flow chart of book cataloging actions, not including production of catalog cards.

In flow charting, each existing activity which accrues significant costs should be identified and placed in proper flow sequence.

Some criteria for choosing activities are:

(1) Each activity should be performed completely by one operator for a given title. When two or more men perform one operation, the activities of each man should be branched.

(2) The activities should be broken down and defined in adequate detail to determine exactly which work is performed. All significant work performed in the process should be incorporated in some activity.

(3) Each activity should be performed several (two or more) times before the next activity is executed. For example, several titles are searched for a precedent** then several titles are placed in either a precedent pile or an original cataloging pile, then several titles are cataloged originally, and so on.

TASK 2

This task determines the average time per work unit for each activity and the reliability of the time values. The first step in this task is to brief each operator in the particular work area on the purpose of and their roles in GAME Analysis. Each operator will receive Form 2 and a list of instructions on an operator's data sheet guide. The data sheet guide will explain:

(1) The flow chart (see Figure 14).

- (a) The activity breakdown.
- (b) The activity symbols (such as B2 for in-house shelf list search).
- (c) The begin time for an activity.
- (d) The end time for an activity.

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* GAME Analysis is discussed briefly in Chapter III of this report.

** A cataloging precedent is any recorded cataloging data on a given title which have been accepted by authority as being valid cataloging information. Library of Congress proof slips and the National Union Catalog listings are potential cataloging precedents.

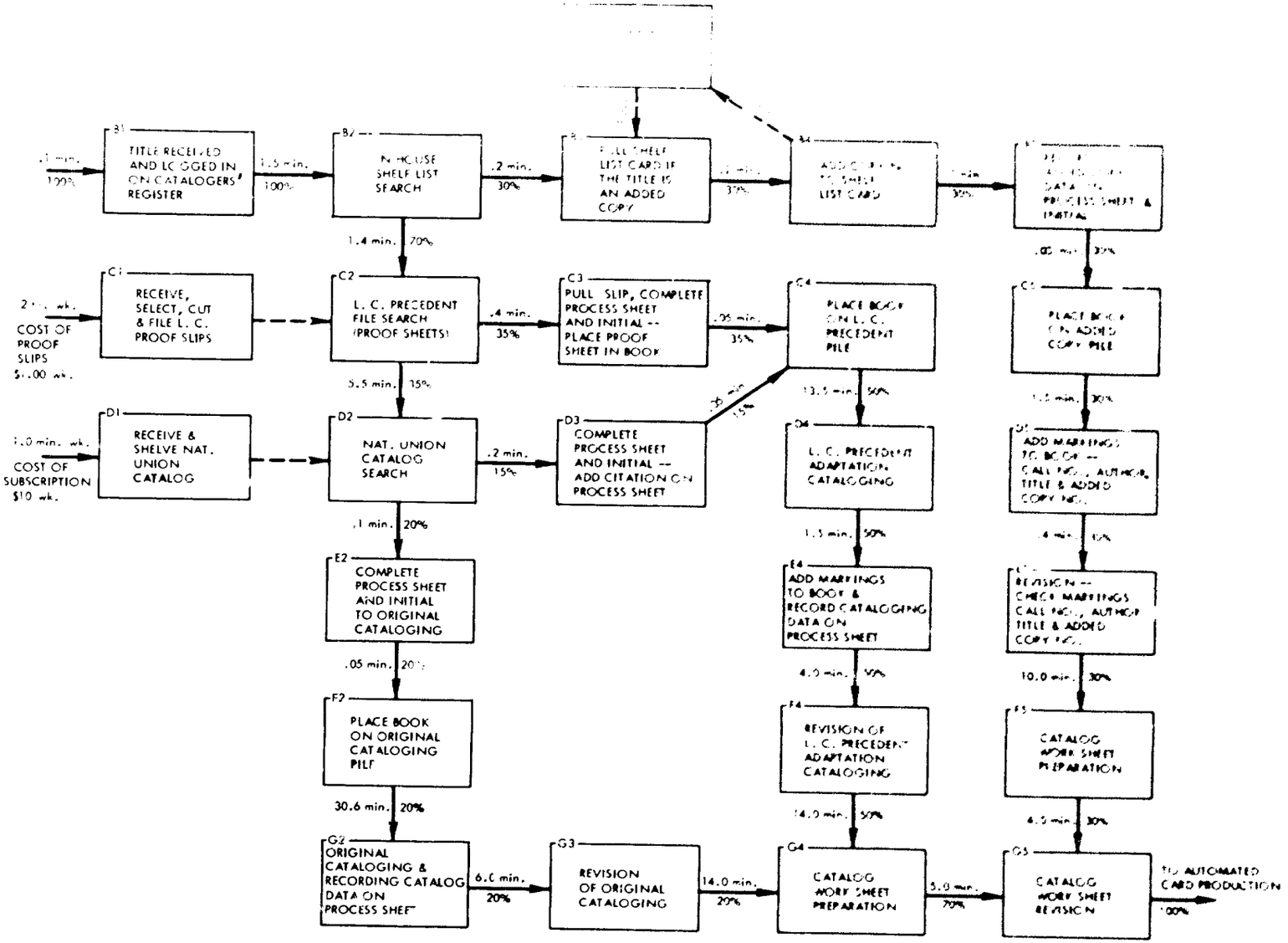

TITLE RECEIVED AND LOGGED IN ON CATALOGERS' REGISTER
IN-HOUSE SHELF LIST SEARCH
PULL SHELF LIST CARD IF THE TITLE IS AN ADDED COPY
ADD CARD TO SHELF LIST CARD
PLACE BOOK ON L. C. PRECEDENT PILE
PLACE BOOK ON ADDED COPY PILE
RECEIVE, SELECT, CUT & FILE L. C. PROOF SLIPS
COST OF PROOF SLIPS $1.00 wk.
L. C. PRECEDENT FILE SEARCH (PROOF SHEETS)
PULL SLIP, COMPLETE PROCESS SHEET AND INITIAL -- PLACE PROOF SHEET IN BOOK
L. C. PRECEDENT ADAPTATION CATALOGING
ADD MARKINGS TO BOOK -- CALL NO., AUTHOR, TITLE & ADDED COPY NO.
RECEIVE & SHELVE NAT. UNION CATALOG
COST OF SUBSCRIPTION $10 wk.
NAT. UNION CATALOG SEARCH
COMPLETE PROCESS SHEET AND INITIAL -- ADD CITATION ON PROCESS SHEET
ADD MARKINGS TO BOOK & RECORD CATALOGING DATA ON PROCESS SHEET
REVISION -- CHECK MARKINGS CALL NO., AUTHOR TITLE & ADDED COPY NO.
COMPLETE PROCESS SHEET AND INITIAL TO ORIGINAL CATALOGING
PLACE BOOK ON ORIGINAL CATALOGING PILE
REVISION OF L. C. PRECEDENT ADAPTATION CATALOGING
CATALOG WORK SHEET PREPARATION
ORIGINAL CATALOGING & RECORDING CATALOG DATA ON PROCESS SHEET
REVISION OF ORIGINAL CATALOGING
CATALOG WORK SHEET PREPARATION
CATALOG WORK SHEET REVISION
TO AUTOMATED CARD PRODUCTION
100%

Figure 14

(2) The kind and amount of work done.

(a) The kind of work for which the activity was performed between the begin time and the end time for the activity. For example, if operation G2 is being performed, the kind of work unit would be original cataloging and recording of catalog data on the process sheet.

(b) The amount of work completed between the begin and end time for the activity. For example, if activity G2 is performed completely for 2 titles between 10:00 AM and 11:00 AM, the number of work units done would be 2 titles.

(3) The time spent on charted activities should be the only time for which the operator must account. For example, personal time, make-work activities and other activities not directly related to performance of the charted activities will not be accounted for by the operator.

The second step is to conduct a work sampling study in order to collect data to determine standard times for each activity. Form 2 is completed by each operator in a given work area (see Exhibit 1, p. 63).

While the operators are performing the activities, a work sampling study is conducted (see Exhibit 2). The GAME Analysis work sampling study form is used for recording data concerning:

(1) The amount of personal time spent, symbol P.

(2) The amount of time spent in transporting materials out of or into the work area, symbol T.

(3) The amount of time spent in receiving or giving instructions, symbol I.

(4) The amount of time spent in unavoidable delays, symbol U.

(5) The amount of time spent related to GAME Analysis, symbol G.

(6) The amount of time spent working on activities, symbol X.

(7) The average pace of working of each operator on each activity, see pace rows.

(8) Explanations of elements--that is, any notes to facilitate understanding of the elements of work or nonwork, see footnote numbers in footnote rows and notes at bottom of Exhibit 2.

Sheet 1 of 1

GAME Analysis
OPERATOR'S DATA SHEET

OPERATOR Mrs. Smith DATE Oct. 2, 1968

ACTIVITY (use symbol - - see operator's data sheet guide)	TIME BEGIN	TIME END	WORK UNITS PRODUCED (kind and amount of work done -- see operator's data sheet guide)
G 2	10:00		Original cataloging and
			recording catalog data on
		11:00	process sheet - 2 titles.
G 3	11:15		Revision of original cataloging
		11:45	- 5 titles.
G 2	11:47	12:00	Original cataloging and
	1:02		recording catalog data
			on process sheet -
		2:35	4 titles.
G 2	2:36		Partial original cataloging
			and recording catalog
			data on process sheet -
		3:00	1 title.
G 3	3:15		Revision of original
		5:00	cataloging - 18 titles.

Exhibit 1

Sheet 1 of 2

GAME Analysis

Work Sampling Study Form

Begin Time 10:00

End Time 11:00

Operator		:05	:10	:15	:20	:25	:30	:35	:40	:45	:50	:55	:60
1. Mrs. Smith	element	X X X X X	X X P P X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	L I X X X	X X X X X
	foot note		1 1									2 2	
Pace		100%	100%	95%	100%	100%	100%	110%	105%	100%	100%	100%	100%
2. Miss Jones	element	X X X X	X X X P P	F X X X X	X U X X X	X X X X X	X Y X X	X X X T T	T T T X X	X X X X X	X X X X X	I I X X X	X X X X X
	foot note				3			4 4	4 4 4			2 2	
Pace		100%	100%	90%	90%	100%	100%	100%	——	100%	100%	100%	100%
3. Mrs. Brown	element	G G G G G	X X X X X	X X X X X	X X X X X	X X X X Y	T T T T T	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X
	foot note	5 5 5 5 5					6 6 6 6 6						
Pace		——	100%	100%	100%	100%	——	100%	100%	100%	100%	100%	100%
4.	element												
	foot note												
Pace													
5.	element												
	foot note												
Pace													

Notes:

(1) Personal telephone call (2) operator 2 asks operator 1 about N. U. C. citation.

(3) waiting for operator 3 to finish with N. U. C. (4) moved books out of area.

(5) studying GAME Analysis operator data sheet and guide.

(6) left area, returned with books.

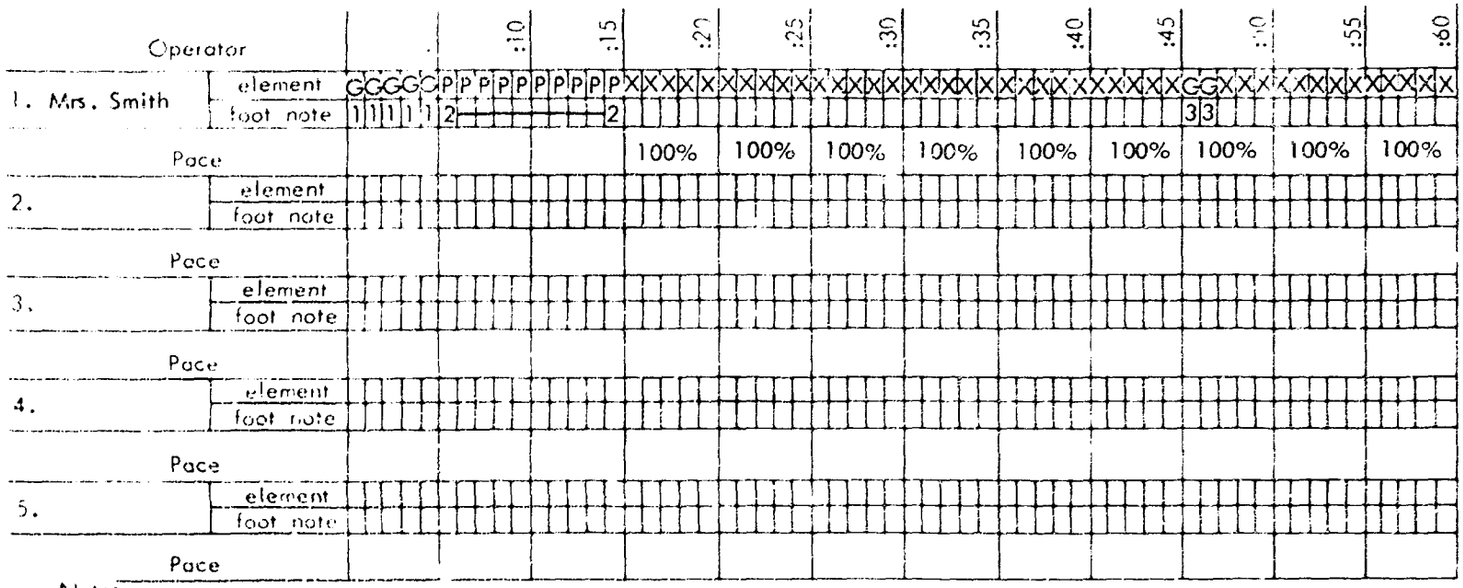
Exhibit 2 - sheet 1 of 2

Sheet 2 of 2

GAME Analysis

Work Sampling Study Form

Begin Time 11:00 End Time 12:00



Notes:

(1) studying & completing GAME study forms. (2) out of area - personal.

(3) completing GAME form.

Exhibit 2 — sheet 2 of 2

An element is recorded for each operator each minute during the study. Each operator is observed once at random intervals during each minute. The element of work or nonwork being performed at the instant of first observation will be recorded as the element for each respective minute.

The third step summarizes the work sampling study data (see Exhibit 3). Activity G2 taken from Exhibit 1 beginning at 10:00 AM and ending at 11:00 AM took a total time of 60 minutes. However, the work sampling study form (see Exhibit 2) must be investigated before the activity time is recorded. Exhibit 2, sheet 1 of 2, shows that Mrs. Smith spent 2 minutes on personal time and 2 minutes in instruction time between 10:00 and 11:00; this is a total of 4 minutes not on the activity, and therefore the time on activity G2 is 60-4 = 56 minutes.

The average pace rating* is:

$$\frac{[100\%+100\%+95\%+100\%+100\%+100\%+110\%+105\%+100\%+100\%+100\%+100\%]}{12}$$

or

$$\frac{1210\%}{12} = 100.9\%$$

Personal time is 2 minutes. Instruction time is 2 minutes. Leveled work time is 100.9%** of 56 minutes = 56.5 minutes. The number of work units produced is 2. All activities which are totally performed for a given number of work units are summarized as in Exhibit 3. Partial performance of an activity such as was performed by Mrs. Smith between 2:36 and 3:00 (see Exhibit 1) will not be summarized.

The fourth step determines the average time for each activity. To obtain a single estimate of the time for performing an activity per title, the leveled work time is divided by the number of work units produced. In Exhibit 3, three single estimates of the time required to perform activity G2 are available. These are:

(1) $\frac{56.5}{2} = 28.3$ min./title,

and (2) $\frac{120}{4} = 30.0$ min./title,

and (3) $\frac{160}{5} = 32.0$ min./title.

---

* For discussion of pace rating see Nadler, Gerald. "Motion and Time Study." New York: McGraw Hill, 1955, Chapter 23.

** Pace ratings are not essential to developing good standards. Pace can be assumed to be 100% for the group, if pace leveling cannot be done with confidence.

GAME Analysis

Sheet 1 of 1

Work Sampling Summary Sheet

date: Oct. 2, 1968

Activity	Time on Activity	Avg. Pace Rating	Trans-port Time	Personal Time	Instruction Time	Unavoidable delay Time	GAME Study Time	Leveled Work Time	Work Units Produced
G 2	56	100.9%	0	2	2	0	0	56.5	2
G 3	30	100%	0	0	0	0	0	30	5
G 2	114	105%	0	0	10	2	10	120	4
G 3	105	100%	0	0	0	0	0	105	18
G 2	177	100%	2	1	3	1	10	160	5

Exhibit 3

Since the three single estimates vary, it will be necessary to derive a weighted estimate for the average time per title.

Single estimate #1 is recorded twice, as in Table 4; single estimate #2 is recorded 4 times and single estimate #3 is recorded 5 times. The number of times the single estimate is recorded depends upon the number of work units produced. Each of the individual recordings will be called a sample member. The sample member single estimates will be designated as y_i, where i = 1,2,3,...n, and y_1, y_2, y_3,...y_n are sample members #1, #2, #3,...#n, respectively.

The average time for an activity is $\Sigma\, y_i/n$. The sample members estimate that the average time for activity G2 is 336.6/11 or 30.6 min./title.

It is desirable that a minimum level of confidence or reliability be attained for the estimates of average time per work unit of each activity. The 5th step, therefore, will be to determine the number of sample members required to meet the minimum level of confidence. When the confidence level is ± 10% $\bar{y}$, 95% of the time, the following formula is used to compute N' (the number of sample members required to meet the desired confidence level):

$$N' = \left[\frac{20(R)(n)}{d_2 \quad \Sigma\, y_i}\right]^2$$

where: R is the range of y_i values,

n is the number of sample members,

d_2 is a constant for a given sample size (see Table 4 for d_2 values).

For operation G2 the N' required to give the desired confidence in $\bar{y}$ is :

$$N' = \left[\frac{(2\ )(32-28.3)(11)}{(3.173)(336.6)}\right]^2$$

$$= \left[\frac{814}{1070}\right]^2 = (.76)^2 = .578$$

Since N' is smaller than n (n=11), no additional sample members are required. If N' is larger than n, then N'-n additional members must be gained by further work sampling. After N' total sample members are available, the N' tests and further samplings are repeated until N' is equal to or smaller than n. By this process an average time per title is eventually derived with the required confidence. The standard time is then recorded on or to the left of the line entering the respective activity (see Figure 14).

Single Estimates

Sample member	y_i
# 1	28.3
# 2	28.3
# 3	30.0
# 4	30.0
# 5	30.0
# 6	30.0
# 7	32.0
# 8	32.0
# 9	32.0
# 10	32.0
# 11	32.0

$$\Sigma y_i = 336.6$$

$$\bar{y} = \frac{\Sigma y_i}{n}$$

$$\bar{y} = \frac{336.6}{11}$$

$$\bar{y} = 30.6$$

n	d_2
2	1.128
3	1.693
4	2.059
5	2.326
6	2.534
7	2.704
8	2.847
9	2.970
10	3.078
11	3.173
12	3.258
13	3.336
14	3.407
15	3.472
16	3.532
17	3.588
18	3.640
19	3.689
20	3.735
21	3.778
22	3.819
23	3.858
24	3.895
25	3.931
30	4.086
35	4.213
40	4.322
45	4.415
50	4.498

Table 4

TASK 3

Task 3 determines the utilization of the group. Our example describes the steps in computing the index of utilization of the cataloging process represented in Figure 14. The 1st step requires an accounting of the books processed in a given period of time, e.g., 1 week, to determine the percentage of total titles processed through each activity during that week. These percentages are then recorded, (Figure 14) below or to the right of the line entering the activity.

The 2nd step computes the "Should-take" time for the titles processed during the week. This is accomplished by solving the following equation:

$$\text{Should-take time} = [(t_1)(f_1)+(t_2)(f_2)+(t_3)(f_3)+\ldots(t_n)(f_n)]N$$

where:

t_1 = the first activity time, i.e., $t_1 = .1$

t_2 = the 2nd activity time, i.e., for activity B2,

$t_2 = 1.5$

$t_3 = 1.4$

$t_4 = .2$

.

.

.

$t_n = (4.0 \times .30)+(5.0 \times .70)=4.7$

f_1 = the fraction of titles processed through first activity, i.e.,

$f_1 = 1.00$

f_2 = the fraction of titles processed through the 2nd activity, i.e.,

$f_2 = 1.00$

$f_3 = .70$

$f_4 = .30$

.

.

.

$f_n = .30 + .70 = 1.00$

and

N = the total number of titles cataloged for the week.

For the example, in Figure 14 Should-take time

$$= [(.1)(1.00)+(1.5)(1.00)+(1.4)(.70)+(.2)(.30)$$
$$+(5.5)(.35)+(.1)(.20)+(.05)(.20)+(30.6)(.20)$$
$$+(6.0)(.20)+(14.0)(.70)+(.2)(.30)+(.7)(.30)$$
$$+(.05)(.30)+(1.5)(.30)+(1.4)(.30)+(10.0)(.30)$$
$$+(.4)(.35)+(.2)(.15)+(.05)(.50)+(13.5)(.50)$$
$$+(1.5)(.50)+(4.10)(.50)+(4.0 \times .30)+(5.0 \times 70)]N$$
$$= [.10 + 1.50 + .98 + .06 + 1.93 + .02 + .01 + 6.12$$
$$+ 1.20 + 9.80 + .06 + .21 + .02 + .45 + .42 + 3.00$$
$$+ .14 + .03 + .03 + 6.75 + .75 + 2.05 + 1.20 + 3.50]N$$
$$\approx 40\ N$$

If the number of titles cataloged in the week is 200, the total Should-take time is 40.00 x 200 = 8000 min. This is approximately 133.3 hours for the week.

The 3rd step determines the utilization of the group. The measure of utilization to be used here is the index of productivity (I), where:

$$I = \frac{\text{Should-take time}}{\text{total time charged to the activity}} = \frac{\text{Standard earned hours}}{\text{measured hours}} .$$

If for the week discussed in steps 1 and 2 the total man-hours charged to cataloging is 190 man-hours,

$$I = \frac{133.3}{190} = .702 .$$

TASK 4

Task 4 is a methods study.* Two key questions should be answered in this study:

(i) Should the present method be performed more efficiently?

(a) Are personal time, transport time, instruction time, unavoidable delay time or other nonwork element times in excess of allowances due to poor management of flow, personnel or training?

---

* See methods study XI in Phase II report, Appendix A.

(b) Is the average pace for the group below the expected pace and not due to factors intrinsic in the method?

(2) Should the present method be changed to improve efficiency?

(a) Are personal time, transport time, instruction time, unavoidable delay time or other nonwork element times in excess of allowances and due to factors intrinsic in the method or can a more efficient method be implemented?

The following steps answer the two key questions for a sample case and describe methods analysis of the example method of cataloging charted in Figure 14. The 1st step is to determine if the present method could be performed more efficiently by improving management of flow, personnel or training. Since the index of productivity is low (.702)*, we should answer question 1(a) by investigating time spent on elements of work and nonwork not charted as activities.

Exhibit 4 is a summary of all work and nonwork elements for the time during the work sampling study. The study observes 4 catalogers working on cataloging activities 8 hours a day for 3 days. The total time on the job was

$$(4 \text{ men})(8 \text{ hrs/day})(3 \text{ days})\left[\frac{60 \text{ min}}{\text{hr}}\right] = 5760 \text{ man-minutes.}$$

Since the operators were completing the operator's data sheet (see Form 2)** during the study, the total time on the job cannot be considered representative of a typical 3-day work period. In order to derive a representative total time on the job the GAME study time (see Exhibit 4) is subtracted from the total time on the job.

Representative total time on the job = 5760-360

= 5400 man-minutes

In order to determine if the present method should be performed more efficiently we shall scrutinize the amount of time consumed in each work and nonwork element not charted on the flow chart.

---

* An index above .75 can be considered adequate, based on the assumption that 15% of staff time is sufficient for personal, fatigue and delay allowances, more than 5% instruction time is excessive and more than 5% transport time is excessive. These allowances are considered reasonable in production plants where fatigue factors and safety hazards are low and where the environment is good. The actual allowance should be set by the library administrator at each library; however, as a base line for efficiency measurement, 25% is a reasonable allowance.

** Forms 1,2,3 and 4 are provided for reproduction purposes and are on pages 25, 80, 81 and 82 respectively.

GAME Analysis

Work Sampling Summary Sheet

Sheet 1 of 1

date: Oct. 7, 1968

Activity	Time on Activity	Ave. Pace Rating	Trans-port Time	Personal Time	Instruction Time	Unavoidable delay Time	GAME Study Time	Leveled Work Time	Work Units Produced
B1 through G 5	4050	94.8%	480	270	300	300	360	38.40	96 titles completely cataloged

Exhibit 4

The percent of time spent on the charted activities = (4050)(100%)/5400 = 75.0%

The percent of time spent in transporting (between activities) = (480)(100%)/5400 = 8.8%

The percent of time spent for the operators' personal use = (270)(100%)/5400 = 5.0%

The percent of time spent in instruction = (300)(100%)/5400 = 5.6%

The percent of time spent in unavoidable delays = (300)(100%)/5400 = 5.6%

The sum of these 5 percentages is 100%.

The percent of time lost due to slow pace

$$= \frac{(4050-3840)(100\%)}{5400} = \frac{(210)(100\%)}{5400} = 3.9\%$$

The total utilization for the period studied is computed by the percent of time spent on the charted activities minus the percent of time lost due to slow pace. For the example above total utilization of the cataloging group = 75.0%-3.9% = 71.1%*.

Since the goal is to attain 75% utilization or better, 3.9% should be gained by eliminating inefficiencies in the present method.

The GAME Analyst is in a position to answer key question #1, part (a)--- are nonwork element times in excess of allowances** due to poor management of flow, personnel or training? The study indicates that transporting materials to and from the cataloging area takes 8.8% of the catalogers' time. Since transporting time greater than 5% is considered excessive, we should attempt to reduce this time. A policy to move books from receiving to cataloging and from cataloging to further processing only once a day may be sufficient to reduce the excessive transport time. Other transporting activities should be investigated to determine if movement between work areas can be reduced.

---

* The utilization of 71.1% is derived from the 3- day work sampling study. The index of productivity .702 is derived from a comparison of one week of work with a standard. Confidence in the analysis improves as the difference in the two measures approaches zero.

** As a loose rule of thumb, time lost in slow pace by fatigue and all other causes should not exceed 5%. Transport time, personal time, instruction time and unavoidable delay time should not exceed 5% each.

Further improvement in the efficiency of cataloging may be realized by reducing instruction time through a comprehensive training program. Unavoidable delay time which is incurred because of unbalanced work stations or cyclical work loads can often be minimized by systematic production controls. If unavoidable delay time accounts for as much as 10% or more of total staff time for book catalogers or book processors and if library management is unable to reduce such delays to 5% or below, professional consultation should be considered for larger libraries.

Excessive personal time is another factor to check in determining if the existing method should be performed more efficiently by managing it more effectively. If personal time is excessive the following actions should be considered:

(1) Establish set break periods.

(2) Require a higher level of production for the group by reducing man-hours assigned to the activity.

(3) If (1) and (2) prove unsuccessful, it may be necessary to encourage group pressures on the most serious offenders by discussing the problem with the group leaders.

Step #2 answers key question #1, part (b)---is the average pace for the group below the expected pace and not due to factors intrinsic in the method?

If average pace is more than 5% below the expected level, that is, if average pace is lower than 95% the following actions should be considered:

(1) Require a higher level of production for the group by reducing man-hours assigned to the activity.

(2) If (1) is implemented and the pace remains slow, a backlog will most likely occur. Pressure on the group to clear up the backlog may improve the average pace of the group.

(3) Various incentive programs may be implemented to improve the pace, such as giving priority for advancement and benefits according to productivity.

(4) Various programs to improve the pace may be implemented, such as equipment and environmental improvements to reduce fatigue and boredom and improve morale.

Step #3 determines if the present method should be improved to eliminate excessive personal time, transport time, instruction time, unavoidable delay time, etc., or to perform the operation at less cost per unit of work.

Assume that the work sampling study shows that 30% of total time lost is caused by personal time, transport time, instruction time and unavoidable delays between activities B2 and E2 (see Figure 14). Assume that further investigation shows that this time is lost due to queuing at the Library of Congress proof slip file and the National Union Catalog shelves, that is, in some cases several catalogers are searching or waiting to search for a precedent at one time. This condition is conducive to increased personal time, instruction time and avoidable and unavoidable delays. Assume that further study indicates that 20% of the titles searched were published within the last 6 months and that only 5% of these titles have a precedent. Also assume that 50% of the titles searched were published within the last 18 months and that 25% of these titles have a precedent.

If a policy not to search for precedents for titles published within 6 months were adopted, a savings in search time would be realized, perhaps, for example 7.5 min. per title. If the policy were implemented for titles 18 months old, assume a savings of 4.0 min. per title realized in Library of Congress precedent searching. However, if these titles were not searched, it would be necessary to do original cataloging on all of them. Since original cataloging requires more time than precedent cataloging, say, for example 17.3 min. per title more, every title which had a precedent will require 17.3 min. more to catalog than if the precedent were searched and found.

In this situation break-even points should be calculated to determine the percent of precedents required to be found in each title age group* to make the search worth while.

Designate Break Even Point by (BEP).

$$(BEP) = \frac{\text{time to search the average title in the age group}}{(\text{original cataloging time/title}) - (\text{precedent cataloging time/title})}$$

For example:

For the 6 months age group, $BEP_6 = \frac{7.5}{17.3} = .43$

For the 18 months age group, $BEP_{18} = \frac{4.0}{17.3} = .23$

For the 12 months age group, $BEP_{12} = \frac{4.8}{17.3} = .28$

---

* A title age group is defined as a group of titles published later than a given date.

To find the age group which should not be searched, the locus of points of the percent of precedents found (PPF) for each age group and the locus of each age group's break even point (BEP) should be plotted. Figure 15 shows the plot of the BEP_i locus and the PPF_i locus, where i can be any age group.

The point at which the PPF_i locus and BEP_i locus intersect* will determine the age group which should not be searched. Figure 15 indicates that the age group 17.6 months or later should not be searched.

A policy should be implemented not to search for precedents for titles less than, e.g., 17 months old, unless by previous knowledge the decision maker knows that there is a precedent available or that there is a high probability of finding a precedent for a given title.

Since a decision maker is required, we shall change the method by adding an activity. This activity involves a decision on cataloging strategy. This activity is represented in Figure 16** as cataloging strategy decision (B2').

The new method is expected to reduce personal time, transport time, instruction time and delay time at the National Union Catalog shelves and at the Library of Congress proof slip file. Furthermore, the new method is expected (1) to reduce the average time/title in searching for a precedent, (2) to reduce the percentage of titles for which the search fails to accomplish the objective of locating a precedent and (3) to improve the flow of materials by reducing the bottleneck effects below that of the old method.

The above example in step #3 is only one kind of methods analysis. This example serves only to demonstrate how methods may be changed to improve efficiency.

TASK 5

Task 5 reviews the findings of the previous 4 tasks and recommends policies and procedures to be implemented to improve the efficiency of the operation, thus completing the GAME Analysis.

---

* This example assumes that the catalogers are doing the searching and that the cost per minute in searching is the same as the cost per minute in cataloging. In a case where the costs are not the same then:

$$BEP = \frac{(Ws)(\text{time to search the average title in the age group})}{(Woc)(\text{Original cataloging time/title}) - (Wpc)(\text{precedent cataloging time/title})}$$

where: Ws = searcher's wage rate, Woc = original cataloger's wage rate and Wpc = precedent cataloger's wage rate.

** Figure 16 is a flow chart of the proposed method. The cataloging activities effected by the change are the only activities charted.

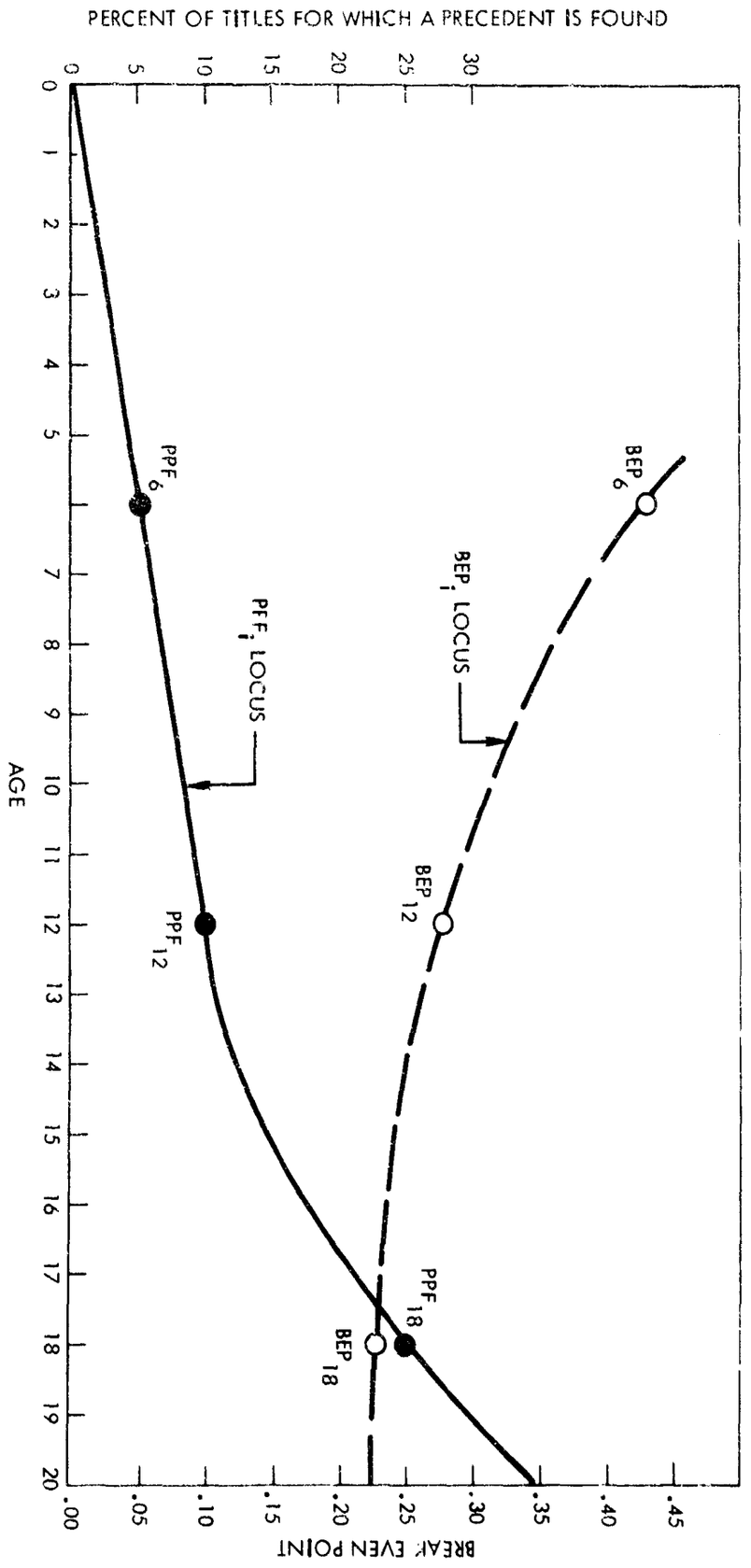

PERCENT OF TITLES FOR WHICH A PRECEDENT IS FOUND
0
5
10
15
20
25
30
AGE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
BREAK EVEN POINT
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
PPF6
PFFi LOCUS
PPF12
BEP6
BEPi LOCUS
BEP12
PPF18
BEP18

Figure 15

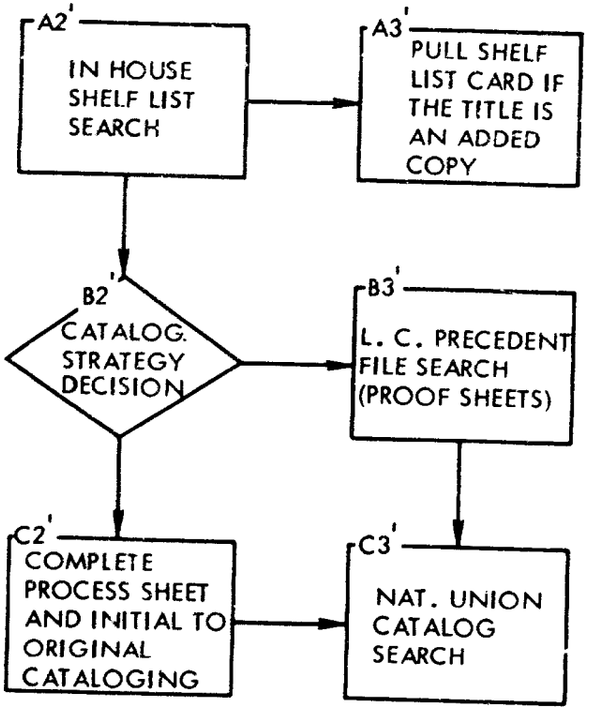

A2'
IN HOUSE SHELF LIST SEARCH
A3'
PULL SHELF LIST CARD IF THE TITLE IS AN ADDED COPY
B2'
CATALOG. STRATEGY DECISION
B3'
L. C. PRECEDENT FILE SEARCH (PROOF SHEETS)
C2'
COMPLETE PROCESS SHEET AND INITIAL TO ORIGINAL CATALOGING
C3'
NAT. UNION CATALOG SEARCH

Figure 16

Sheet _____ of _____

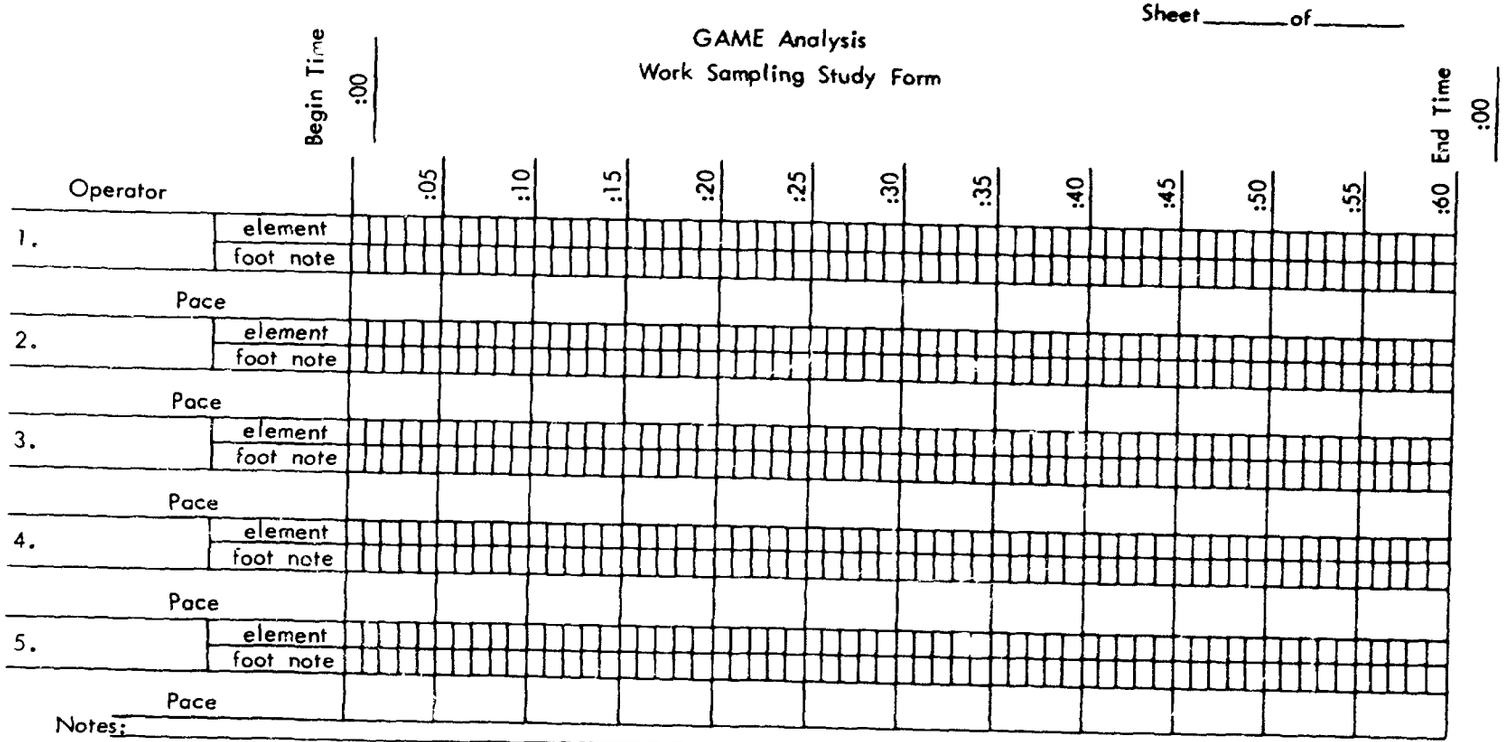
GAME Analysis
OPERATOR'S DATA SHEET

OPERATOR _____ DATE _____

ACTIVITY (use symbol -- see operator's data sheet guide)	TIME BEGIN	TIME END	WORK UNITS PRODUCED (kind and amount of work done -- see operator's data sheet guide)

Sheet _____ of _____

GAME Analysis
Work Sampling Study Form



GAME Analysis

Sheet____ of ____

Work Sampling Summary Sheet

date: _____

Activity	Time on Activity	Ave. Pace Rating	Trans-port Time	Personal Time	Instruction Time	Unavoidable delay Time	GAME Study Time	Leveled Work Time	Work Units Produced

VIII. APPLICATION AND RELIABILITY OF SCORE, SCOUT, CORE AND GAME ANALYSES

The majority of the time spent during the library visits of Phase III was for the purpose of determining the feasibility of collecting data essential to performing analyses of library efficiency and effectiveness by using the tentative methods recommended in the Phase II report.

This chapter represents the findings and discusses the applicability of methods used in SCORE, SCOUT, CORE and GAME Analyses according to library size and types of library operations and services.

A. Applicability & Reliability of SCORE Analysis

Sample data for SCORE Analysis were collected at three A.T.L.'s. Reliable estimates of the percentage of needs passing several events in reference search service (librarian conducts search) were derived from a study of a total of 69 or fewer needs for the service at two A.T.L.'s. The percent of needs passing each event based on a sample size of 69 or fewer needs entering the event was found to predict the probability of occurrence of several events within ± 10%, 95% of the time.

Table 5 shows the data collected at one library for determining the effectiveness probabilities. We shall refer to this library as library #1. The percent of occurrence for event 1 for period 1 is :

$$\frac{32}{33} (100) = 97\%.$$

The percent of occurrence for event 1 for period 2 is:

$$\frac{36}{36} (100) = 100\%.$$

Table 6 shows the percent of occurrence of each event for the two periods.

If for a given event the percent of occurrence for different periods is relatively stable, the probability of event occurrence can be determined. This probability predicts the percent of occurrence of the event. At library #1 the total number of needs processed during the 5 day study was 69. The average percent of occurrence of event 1 for the 5 day period is:

$$\frac{68}{69} (100) = 98.5\%.$$

The probability of event occurrence is expressed as the fractional part of the needs passing the event. For library #1, the probability of event 1 occurrence is:

$$\frac{68}{69} = .985.$$

Event	Period 1, 2-1/2 day duration		Period 2, 2-1/2 day duration	
	Needs into Event	Needs Passing Event	Needs into Event	Needs Passing Event
1. Need communicated -	33	32	36	36
2. Search begun -	32	27	36	36
3. Candidate document identified -	27	24	36	34
4. Retrieved in the required time -	24	19	10	8
5. Relevant -	16	16	8	7

TABLE 5

Event	% of occurrence		Avg. % of Occurrence	Probability
	Period 1	Period 2		
1	97%	100%	98.5%	.985
2	84%	100%	92.0%	----
3	89%	94%	91.5%	.915
4	79%	80%	79.5%	.795
5	100%	88%	94.0%	----

TABLE 6

A minimum level of confidence is required of the average percent of occurrence of each event before the probability of event occurrence can be expressed.

The purpose of the reliability tests in Phase III was to determine the study time required in order to derive event probabilities with a confidence of ± 10%, 95% of the time at the sample libraries.

The following equation was used to determine the number of 2-1/2* day periods to be studied to attain the required confidence in the probability of occurrence of the event (i), where i can be any event:

$$N_i' = \left[\frac{20(R)(N)}{d_2 \Sigma X_i}\right]^2$$

where: N_i' = number of 2-1/2 day study periods required,

R = range of percent of occurrence values between the period of highest occurrence and the period of lowest occurrence,

N = the number of 2-1/2 day periods studied,

d_2 = a constant for a given N value (see Table 4),

ΣX_i = the sum of percent of occurrences of event i for each period.

N_i' for event 1 at library 1 is:

$$N_1' = \left[\frac{(20)(3)(2)}{(1.128)(197)}\right]^2 = \left[\frac{120}{222}\right]^2 = (.54)^2.$$

$$N_1' = .29$$

Since N_1' is smaller than N , no additional 2-1/2 day periods should be studied. That is, the probability .985 is accurate within ± 10%, 95% of the time, as a predictor of the percent of needs for which event 1 occurs for any 5 day period.

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* 2-1/2 days was used as the time interval for the library studied. The time interval depends on the rate of incoming needs. The time interval chosen should include at least 25 incoming needs.

N_2' (for event 2) at library 1 is:

$$N_2' = \left[\frac{(20)(16)(2)}{(1.128)(184)}\right]^2 = \left[\frac{640}{207}\right]^2 = (3.10)^2$$

$$N_2' = 9.6$$

Since N_2' is larger than N_2, additional periods must be studied to get the probability of event 5. After each additional period N' should be computed to determine if the required confidence in the average percent of occurrence has been reached to permit expression of the event probability.

The 5 day study at library #1 failed to generate enough data to express the probability of events #2 and #5. The N_i' calculations indicated that 24 day study of occurrences of event 3 is required; 24 days is the longest period required to derive any event probability for the service at library #1. Therefore, it is predicted that in a period of approximately one month the probabilities of occurrence of all events can be derived for reference search service at library #1. Libraries which have fewer than 10 needs per day in reference search service may require longer studies.

For the second library (library #2 data were generated over a 2 months period, and all the event probabilities were derived with the desired confidence. This smaller library has a staff size of 7. Assuming library #2 is representative of its staff-size group in the amount of reference search service given, the study indicates that SCORE Analysis effectiveness measures with the desired confidence can be derived at libraries with a staff size of 7 or more within approximately 2 months.

In small libraries the time required to derive event probabilities, with a confidence of ± 10%, 95% of the time, may be prohibitive. Small libraries, in this case, are defined as those which process reference search service needs at an average rate on the order of 3 per day or less. If less confidence is expected and more time is allowed, reference search service can be measured by SCORE Analysis even at smaller libraries.

Data for effectiveness measurement of users search service by SCORE Analysis were collected at a third A.T.L. (library #3). The data were generated over an 11 work day period. The probabilities of event occurrence were derived with the required confidence during this period. The data for percent of occurrence of events were collected by questionnaires given to the users of the service. The response in returning the questionnaires was poor (approximately 43%). This poor response tends to bias the sample; however, regardless of the bias we can reasonably assume that better

means of getting user feedback and a study of up to 20 work days would make SCORE Analysis of user search service feasible at all libraries with a staff size of 4 or more. If less confidence and/or more time could be allowed for the study, it is feasible that SCORE Analysis effectiveness measurements of user search service could be conducted at all A.T.L.'s.

A complete SCORE Analysis requires the generation of cost data. Since library costs are relatively stable for labor and acquisitions, there is a high probability that reliable cost data can be determined within the time required to determine reliable effectiveness measures. Further discussions of costs reliability will be presented in Section D of this chapter.

B. Applicability and Reliability of SCOUT Analysis

Tests were conducted at 4 A.T.L.'s to determine the feasibility of measuring the effectiveness of services and operations with methods which depend upon the use of librarians' subjective judgments as to utility values of the services and operations. These tests are applications of utility analysis as described in the Phase II report. We will undertake here to test the reliability of these methods in two respects:

Test 1. The extent to which utility judgments of a given service or operation made by one librarian agree with the judgments made independently by another librarian.

Test 2. The extent to which the utility judgments made by a librarian agree with his judgments of how funds should be allocated.

The reliability of the utility analyses in test 1 was not considered high enough to recommend the use of utility analysis using subjective judgments without an objective basis for the judgments. The reliability of the utility analysis in test 2 was highly significant.

At each of the 4 libraries the utility analysis indicated that, in order to maximize utility of the services, certain changes should be made in the allocation of funds. At 3 of the 4 libraries the librarians agreed that these changes in budgeting should be made to improve effectiveness. In effect, test 2 showed that for 5 out of the 6 librarians tested their subjective judgments of utility and their budgeting criteria were consistent. However, because in test 1 the reliability was not significant, we doubt the feasibility of using a purely subjective utility analysis.

To improve the credibility and reliability of utility analysis the original concept has incorporated some of the validated objective measures of effectiveness utilized in SCORE Analysis to form SCOUT Analysis.

SCOUT Analysis uses a base for utility judgments. This base of utility for services is the average number of needs met by a service in a given period of time with objective leveling. The base of utility for operations is derived from the change in the number of needs met (ΔM) due to a change in the operations output ΔO, i.e., base utility for operations $= \Delta M / \Delta O$. The reliability of this measure has been established as described in Section A of this chapter. Reliable estimates of the change in utility due to changes in operation output can be derived by studies of previous needs met and/or not met. For example, if an average of 100 needs in reference search service are met per week and if an average of 10 of these needs are met through 4 man-hours/week of interlibrary loan activities, a change in interlibrary loan activity from 4 man-hours/week to 0 man-hrs/week would cause the average number of needs met per week to change from 100 to 90.

The $\frac{\Delta M}{\Delta O}$ measurement concept of SCOUT Analysis is based upon one of the same data elements as the effectiveness measurement of SCORE Analysis is based upon, that is, the number of needs met. Therefore, $\frac{\Delta M}{\Delta O}$ is as reliable for measuring base utility as is the SCORE delta index for measuring cost-effectiveness. A confidence of $\pm$ 10%, 95% of the time, should be attainable for $\frac{\Delta M}{\Delta O}$ by a study of approximately the same duration as is required to perform SCORE Analysis.

SCOUT Analysis has been introduced to account for the value of needs met, and the raw number of needs met is not a valid measure of the kind of effectiveness denoted by the definitions of value and utility. For example, it is conceivable that the typical need met in reference search service has a greater value than the typical need met in predetermined circulation of periodicals. SCOUT Analysis, therefore, allows for leveling of the $\frac{\Delta M}{\Delta O}$ measures according to the judgment of a qualified SCOUT Analyst. The credibility of these judgments cannot at this time be supported by measures of statistical reliability; however, this fact should not be used to discount the validity of the approach.

Section D of this chapter discusses GAME Analysis which utilizes Group Attainment Program (GAP). GAP is a technique which has received wide acceptance as a means for measuring manufacturing efficiency. GAP uses a leveling principle to adjust the amount of time spent on an operation to account for the operator's pace of working. Regardless of the subjective nature of leveling, it is considered to be a valid criterion for measuring group performance. If leveling factors are cautiously applied, the validity of the overall measurement of efficiency, effectiveness, value or utility can be improved. By cautious application we mean that an analyst should not level the time on an operation or the base utility beyond his confidence or ability.

As the analyst gains experience he will be able to level more severely. For example, a beginning SCOUT Analyst should not level reference search and circulation service as 0.5 times the value of user search and circulation service without reliable data to support such a severe leveling factor. If the analyst's study shows that the typical user search need met has twice the effect that the typical reference search need met has upon increasing or decreasing the solution probability of approaches to meeting the user mission, he can reliably level reference search service needs at 0.5 (X), where X is the leveled utility base per need* in reference search.

To summarize, SCOUT Analysis is a feasible method for measuring library efficiency and effectiveness and is recommended for use by trained analysts at all A.T.L.'s for all operations and services.

C. Applicability and Reliability of CORE Analysis

CORE Analysis is designed to develop standards for efficiency at given levels of effectiveness. The standards are based on norms for a group performing within a definable range of effectiveness or quality. The standard for a quality range will be the expected level of performance, that is, the quality should not range below the lower limit of the defined quality range. Furthermore, the unit cost should not be higher than the standard cost per unit, unless the quality can be demonstrated to be proportionally high to justify the additional unit costs or unless extenuating circumstances prevail.

Basically CORE Analysis is a means for identifying areas where operational performance standards for a population of libraries are feasible, and for providing a tool for developing such standards. The measure of performance is derived by comparison of actual unit costs and quality to standard unit costs and quality.

The applicability of CORE Analysis depends upon:

(1) the ability of the analyst to define narrow classes of quality;

(2) the ability of the analyst to define quality classes in such a manner that the cost-output correlations of the members in these classes are sufficiently high;**

(3) the extent of performance conformity among the libraries being studied.

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* The leveled utility base per need is arbitrarily set at 10 for a middle ranking service. The service assigned the value 10 can serve as a bench mark for judging the leveled utility base per need for all other services.

** A correlation coefficient of 0.80 should be considered adequate for the development of tight and reliable standards.

In Phase II, correlation analyses were conducted on a variety of data classes. Significant curvilinear correlations were found between the outputs of several routine operations and their costs. Conditional standards for varying operational outputs can feasibly be applied to these operations. These conditional standards should express unit cost as a curvilinear function of quantity of output. CORE Analysis is designed to derive linear function standards, that is, for a given level of effectiveness the CORE standard is expressed as a linear function. For example, the standard for descriptive cataloging may be expressed by linear equations of the general form $y = a + bx$. For the example in Chapter VI, p. 58.

$$y = -12.4 + 1.1x,$$

where: y = weekly cost of descriptive cataloging,

and x = the number of titles descriptively cataloged per week.

This CORE standard will be applicable for a limited range of x values, where the x value is the output quantity. If this standard is based upon data collected from 10 libraries performing descriptive cataloging, where the library with the lowest x value catalogs 20 titles per week and the library with the highest x value catalogs 224 titles per week, the standard will apply only to libraries cataloging between 20 and 224 titles per week. Other factors should be considered in judging the applicability of a CORE standard such as the following:

(1) The validity of the standard improves as the value of the constant (a) approaches zero. The confidence interval for y is $\pm \frac{a}{y}$ (100%) of y, i.e., actual cost should be within the range $y \pm \frac{a}{y}$ (y) or $y \pm a$.

(2) If the value of (a) is negative, the library should be allowed to deviate from the standard cost y by a factor of -$(a) before requiring the administrator to account for cost above the standard cost, that is, if a = -$20.00, the actual cost should not be greater than y - $(a) or y-(-$20.00) or y +$20.00.

(3) Libraries which traditionally work below the standard cost should be required to account for any recurring drop in efficiency (E). For example, if a library is measured by a CORE standard for January, February and March and E = 1.20, E = 1.25, E = 1.15, respectively, and for the months of April, May and June E = 1.00, E = .95, E = 1.05, respectively, the apparent drop in efficiency during April, May and June should be accounted for, even though the work is to the standard.

Based upon the data collected in Phase II, CORE standards are feasible for acquisitions, cataloging, circulation activities and bibliography compilation at A.T.L.'s with staff sizes of 10 or less. CORE Analysis is not a feasible tool for developing standards at larger libraries, because it has been observed that they do not conform to the linear equations which best fit the smaller libraries. CORE Analysis is a feasible tool for developing standards for large groups of small libraries which are characterized by close conformity. The libraries with staff sizes over 10 do not constitute a large group and do not conform closely. That is, as viewed in a cost-output scatter diagram these larger libraries are few and far between (broadly scattered). The feasibility of developing adequate CORE standards decreases as the scatter broadens.

Efficiency standards at larger* libraries should be developed by GAME Analysis (see Chapter VII).

D. Applicability and Reliability of GAME Analysis

A test conducted during Phase III at one A.T.L. with a staff size of 22 indicates that a 5-day GAME study is adequate to develop reliable standards with a confidence level of ± 10%, 95% of the time, for cataloging activities utilizing 4 or more full-time group members. The results of this test support the feasibility of using GAME Analysis for developing time and cost standards for routine operations at large libraries. On the basis of the test results it is feasible that reliable GAME standards, expressed as expected time/unit or cost/unit, for routine operations such as acquisitions, cataloging, book processing, routine reference searches, circulation activities and bibliographic compilation can be derived for large libraries within a reasonable study time. The approximate amount of time required to derive a reliable standard for an activity can be predicted by a preliminary GAME Study. This is done by first computing N' (the number of sample members required to meet the desired confidence level), see p. 68. The second step is to determine T (the time required to study one sample member). An estimate of the time required to derive a reliable standard for the activity can then be computed by the formula:

$$\text{study time} = N' \times T.$$

GAME Analysis can be used more practically at larger libraries, since in general the study will require less time and expense. Furthermore, it is probable that a greater savings will be realized from the study at larger libraries. GAME Analysis is to be used primarily as a tool for measurement of efficiency. However, effectiveness of the outputs of operations (quality of outputs) must be defined and controlled in GAME Analysis. The measure of effectiveness in GAME Analysis is a simple quality check to determine if a predetermined quality standard is being met.

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* Larger libraries are those with staff sizes of 11 or more.

IX. CONCLUSIONS

This contract study undertook to establish criteria for the evaluation of Army Technical Library operations and services. In terms of the study, criteria were defined as concepts usable to achieve the objective. In this study the contractor is charged to define each criterion which is recommended, and to provide a method of implementing the criterion with the purpose of determining library effectiveness.

In carrying out the work of the study, we have adhered to the original division of the project into three phases. In the first phase we conducted a thorough search of the literature to determine the state-of-the-art. This search was aimed not only at locating criteria and methods which have already been identified, developed and applied to evaluation of library operations and services, but also at searching out techniques outside the field of library sciences which could be applied to library problems. A very considerable number of such references were located in both cases. These findings were reported, along with certain observations as to the directions the work should take, in the final report of Phase I.

In the Phase II portion of the study, we identified a number of different approaches to the task of identifying criteria, and sought out data and information by which these approaches could be analyzed. These data and collections of information were sought in a number of reports of prior statistical studies as well as via visits to a selected sample of A.T.L.'s by personnel of John I. Thompson & Company. From the experience gained in this process we enunciated a number of candidate criteria and originated certain methods or techniques which we deemed adequate for implementation of the criteria and for evaluating library operations and services performance in terms of efficiency and effectives.

Phase III of the contract study was devoted to examination of the criteria and development of detailed implementation methods. This involved additional visits to a number of A.T.L.'s for discussions with library administrators, for gathering certain additional data and information; for developing the methods into systematized procedures and applying those procedures to library situations. Finally, Phase III was devoted to detailing these procedures into definite series of tasks which could be followed by evaluation personnel in applying the methods in specific library cases.

The final outcome of the work, therefore, as represented by this report, is a number of criteria which represent rather fundamental aspects of the operations of, and the services and products produced by, A.T.L.'s. Accompanying these criteria are four basic procedures which we might identify as management techniques. Actually, several classical management

techniques or modifications of techniques are embodied in these four systematized procedures. We have assigned acronyms to these procedures from phrases describing the actions taken in the system:

SCORE - Service COmponents Reliability and Efficiency Analysis
SCOUT - Service COmponents UTility Analysis
CORE - COrrelation, Regression and Effectiveness Analysis
GAME - Group Attainment and MEthods Analysis.

The systematized procedures do not implement all the criteria which arose out of the work. Nor are the systematized procedures the only ones which could have been originated and developed. However, they do embody what we judged to be the most applicable criteria and the most useful methods for development at the present time with the data available. We believe, moreover, that certain additional work should be done with regard to application of the criteria not treated finally herein and the development of management procedures which are available at the present time for criteria already recognized.

In carrying out research and development of the nature of this contract work, the full value of the project is often not attained because the development ceases prematurely. In the case of the systematized procedures developed in this work, they should be applied, and evaluators familiarized with them in detail, before their real worth can be assessed. It is our recommendation, therefore, that these techniques be applied in a sufficient number of technical libraries to determine through usage itself whatever refinements are necessary to convert them to standardized practices.

We recommend the start of an organized effort to apply the methods at a sample of Army Technical Libraries. We further recommend that evaluators be trained in the use of the methods and that the methods be applied according to the following criteria:

1. For measurement of efficiency and effectiveness at smaller libraries (staff size of 10 or less):

   1st priority: SCOUT Analysis
   2nd priority: SCORE Analysis
   3rd priority: CORE Analysis
   4th priority: GAME Analysis.

2. For measurement of efficiency and effectiveness at larger libraries (staff size of 11 or more):

   1st priority: SCORE Analysis
   2nd priority: SCOUT Analysis
   3rd priority: GAME Analysis.

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13 ABSTRACT

This final report assesses and recommends criteria and methods for evaluating the performance (effectiveness and efficiency) of technical library operations and services. These criteria and methods include those identified in the state-of-the-art of library evaluation (existing criteria and methods) and those developed by adoption of criteria from the state-of-the-art "scientific management" (candidate criteria and methods).

The final product is a list of recommended criteria and associated methods of implementing them. There are 4 proposed techniques:

(1) SCORE Analysis - a technique to measure the effectiveness of a service and the associated change in effectiveness due to a change in operations or costs.

(2) SCOUT Analysis - a technique to determine the optimum balance between operations which yields maximum effectiveness within budget constraints.

(3) CORE Analysis - a technique to derive unit cost standards for given operations which produces a given quality of output.

(4) GAME Analysis - a technique to eliminate unnecessary work or excessive delays; to arrange work in the best order; to standardize usage of proper work methods, and to develop time standards to accomplish essential events.

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